

Recd 25/3/12

6177

THE S I S  
FOR THE DEGREE OF M.D.  
on  
INTRA-OCULAR TENSION and the GENERAL BLOOD  
PRESSURE.  
With Special Reference to the Aetiology of Glaucoma  
by  
ALEXANDER MACRAE, M.A., M.B., Ch.B., D.T.M. & H.

M.D. 1912.

March, 1912.



# INDEX .

---

- INTRODUCTION. pp. 3 & 4.
- PART I. The Intra-ocular Tension and its measurement. pp. 5-40.
- PART II. Blood Pressure Measurement, pp. 41-51.
- PART III. The Relation of Blood Pressure to Eye Tension, pp.52-59.
- PART IV. The Role of Blood Pressure in the Aetiology of Primary Glaucoma. pp.60-108.
- APPENDIX I. Notes on Cases of Glaucoma examined, pp.110-142.
- APPENDIX II. Eye Tensions in Normal Eyes. pp.143,4.
- APPENDIX III. Eye Tensions in Myopia, p.145.
- APPENDIX IV. Cases apart from Primary Glaucoma in whose eyes I found tensions beyond 25 mm.Hg. pp.146-7.
- APPENDIX V. Cases in eyes not operated on, in whom I found Eye Tensions below 15.5 mm.Hg. pp.148-50.
- APPENDIX VI. List of References. pp.151-153.
-

# INDEX OF CHARTS.

---

PRESSURE CHARTS	PAGES.
I.	22.
II., III.	23.
IV, V, VI.	24.
VII.	93.
VIII.	94.
IX.	96.
X.	97.
XI.	98.
XII.	99.

## PERIMETER CHARTS OF EYEBALL.

---

Glaucoma Case III.	112.
VIII.	116.
X.	119.
XVII.	126.
XXV.	134.
XXX.	140.

---

# INTRODUCTION.

---

The question of the relation of blood pressure to intra-ocular pressure has been entered into by more than one observer.

My excuse for approaching the same subject again is that, on the one hand, our means of estimating blood pressure clinically have been improved since most of these previous investigations were made; and, on the other, that the recent invention of Schiötz's tonometer has given us an instrument whereby we are able clinically to note with accuracy the smallest rise or fall in the intra-ocular pressure.

So far as I know, none of those who have studied this subject before have used (or at least have recorded their use of) the tonometer in conjunction with the sphygmomanometer, while the most recent writer on the subject, Kümmell, has stated that some light may be shed on this admittedly difficult problem by such an investigation.

The thesis falls into four main divisions.

(1)/



(1) Tonometry..

(2) Blood Pressure Measurement.

(3) The relation of the Blood Pressure to the Eye Pressure.

(4) The question of the place high Blood Pressure has in the aetiology of Glaucoma.

---

## P A R T I.

THE INTRA-OCULAR TENSION AND ITS MEASUREMENT.

---

HISTORICAL.

---

It has long been a recognised fact that if pressure is made on the eyeball through the upper lid with the fingers, the feeling of resistance which the eyeball gives varies greatly; some eyes being markedly soft and offering very little, if any, resistance, while others feel as hard and unyielding almost as a stone. Between these two extremes, every degree of hardness and softness may be found.

The importance of this part of the examination of the eye was emphasised when it was noticed by Mackenzie and von Graefe that in inflammatory glaucoma increase in hardness of the eye (or intra-ocular tension) is the essential and most important symptom. Starting from this observation, attempts were made by operative means to permanently reduce the high tension. Mackenzie, by repeated paracentesis of the cornea did not succeed in effecting a permanent reduction, but von Graefe was more successful. And if one must concede that his operation of/

of iridectomy in this condition was based on a  
 (1)  
 false pathology, the glory is his none the less of  
 introducing a procedure which has, since his first  
 operation in 1856, saved many thousands of eyes  
 which otherwise must have gone on to total blindness.

The year 1856 was of special significance  
 in regard to glaucoma in another direction, for in  
 that year the pressure excavation of the optic nerve  
 in the disease was first pointed out by Heinrich  
 Müller. Shortly afterwards the ophthalmoscopic ap-  
 pearances of this excavation (or "cupping") were  
 accurately described by Weber and Forster. This  
 was also a great forward step in regard to the dis-  
 ease. Hitherto only the inflammatory cases had been  
 diagnosed as glaucoma. Now it was seen that the same  
 ophthalmoscopic picture was given in certain cases  
 which had previously been classed with other undif-  
 ferentiated diseases as amaurosis, and it was re-  
 cognised that in many of these cases, if careful  
 and repeated examination were made, the fingers were  
 able to appreciate a rise of tension in the eye ball.

There still remained, however, a class of  
 case in which the ophthalmoscopic picture of glaucoma  
 was present, but at no time was an increase of ten-  
 sion detected in the eye-ball. Such cases were  
 classified/

classified as cases of glaucomatous "excavation without increased tension". These cases will be referred to later.

But if in glaucoma as a rule the finger is able to appreciate a rise of intra-ocular pressure, there are other conditions in which the eye is noticeably softer than normal. These cases do not form so marked a clinical entity as glaucoma, but among them should be noted certain stages in some forms of iridocyclitis; and also cases in which detachment of the retina has occurred.

In order to record the results of examination of the eye tension, it has been the custom to use the notation T+1, T+2, T+3, for the cases in which the eye was found to be harder than normal; and T-1, T-2, T-3, for cases in which the eyes were soft; T+3 and T-3 representing the opposite extremes. Estimation of tension by the fingers not satisfactory.

It has long been felt, however, that palpation was at best only a rough-and-ready method of measuring the tension, and one which lacked scientific accuracy. The fingers of different observers vary greatly in their sensitiveness with regard to pressure, and observers were conscious that the sensitiveness of their own fingers varied in delicacy at/

at different times. It is not difficult to tell when an eye is of the T+3 or T-3 variety, but it often becomes a difficult question to say whether an eye has or has not a + tension, especially where the patient has lost the other eye, or where the other eye is in such a pathological condition that its examination is useless for purposes of comparison.

And besides, cases may occur, after operation for glaucoma for example, where it is obvious that the one eye is harder than the other, but it is difficult to say whether the harder eye is or is not within the limits of normal tension.

In order to estimate the intra-ocular pressure with the scientific accuracy of the physiologist, it is necessary to introduce a canula into the eye-ball and connect it with some form of manometer. In this way the pressure can be accurately measured, just as in the cognate problem of the arterial pressure the most accurate results are obtained by introducing a canula into an artery.

On the human subject, however, neither of these proceedings is in ordinary circumstances justifiable. One might conceivably introduce a canula into the popliteal artery just before an amputation through the thigh, or connect the anterior chamber/



chamber of an eye which was immediately to be enucleated with a manometer.

But, however great the oculist's confidence in the asepticity of his technique, he would be a bold if not a reckless man who would plunge a canula into the anterior chamber of a glaucomatous patient's eye, merely to satisfy himself as to the actual degree of pressure present in the eye-ball. Even if no harm were to result from the procedure, it is obviously one which could only be adopted under very special conditions, and could never be used for the routine examination of cases in which it was desirable to take a frequent note of changes in the intra-ocular pressure.

#### Measurement of Intraocular Tension clinically.

To obviate this difficulty, various attempts have been made since the days of von Graefe to estimate the tension of the eye-ball by an instrument which should give a reliable approximation to the manometric reading, without necessitating puncture of the eye-ball; in the same way that various forms of sphygmo-manometer have been devised as clinical methods of testing the arterial pressure.

Of the various forms devised, those of  
Maklakow/



Maklakow and Schiötz are the two which have been most widely used; and of these two that of Schiötz has proved itself the more useful and is daily coming into greater favour.

#### Schiötz's Tonometer.

As a full description of this instrument has been lately published in this country by Cridland (2), it is unnecessary here to describe it in detail.

The assumption on which its design is based is virtually that which we make in estimating intra-ocular tension by the fingers, viz., that the indentability (if I may coin the word!) of the eye-ball is in inverse proportion to its tension, and is identical in eyes of the same tension.

The instrument, which is of a known fixed weight, terminates below in a concave plate, whose curvature is as nearly as possible that of the normal cornea (radius of curvature = 15 mm.), and is applied so as to rest directly on the cornea, the patient being in the supine position and looking straight upwards. The tonometer is held in the operator's hand by a sliding collar which runs on friction wheels in such a way that the instrument can be applied without any pressure being exerted by/

by the operator on the eye-ball.

Through the centre of the plate which rests on the cornea, a rod of 3 mm. diameter passes. To the upper end of this rod one of a series of known weights (5.5, 7.5, 10 and 15 grammes respectively), can be readily attached. The amount of indentation of the cornea produced by this rod, plus the attached weight, is recorded by a lever on a millimetre scale. If the eye is of normal or sub-normal tension, the 5.5 g. weight is sufficient to indent the cornea and give a reading on the scale. In eyes of higher tension, this weight may not indent the cornea at all, in which case the lever remains beyond the zero of the scale, or may give a reading of less than 2 mm. In either case the next higher weights must be used successively until one is reached which gives a reading between 2 and 4 mm. on the scale. This reading is then compared with a chart furnished with the instrument from which the tension in mm. Hg. which it represents can be readily seen. This chart has been made by Schiötz by comparison with the actual pressures given by a manometer connected with the interior of the eye, and its readings may be taken as fairly/

fairly accurate.

### Sources of Error in Tonometry.

All impression tonometers are subject to three chief sources of error, which are summarised by Cridland (*loc. cit.*) as follows:-

(1) The indentation of the globe is dependent on the curvature of the surface, a variable quantity in different eyes and in different parts of the same eye.

(2) The intra-ocular pressure increases with any pressure upon the globe, such as the weight of the instrument, and the pressure unconsciously exerted by the fingers in applying the instrument; and

(3) The indentation is dependent on the extensibility of the membrane - a variable quantity in different eyes.

In Schiötz's tonometer, however, these defects are minimised in the following ways:-

(1) The area indented by the rod of the tonometer has a diameter of only 3 mm., and the variations in curvature of so small a surface are almost negligible.

(2) The weight of the instrument (apart from the detachable weight) is small and is constant, and/

and though it may produce a slight increase in intra-ocular pressure, this will be the same in all cases. As a matter of fact, this hypothetical increase in intra-ocular pressure is very rapidly eliminated by the tendency of normal eyes to diminish in tension during successive applications of the tonometer (see p. 22 ), while the pressure exerted by the fingers is minimised by the ingenious sliding collar already mentioned and its friction wheels, and is practically nil. This is proved by the fact that when the instrument is properly held in position on the cornea, the collar may be moved gently up and down without producing any movement of the lever on the scale.

With regard to the third source of error, this idea is based on the view given expression to by Fuchs (3 ), that on account of the greater rigidity of the sclera in old people, their eyes feel harder as tested with the fingers than those of young people. This, however, does not in my opinion hold with regard to the cornea. I have failed to find in the non-glaucomatous a progressive increase in the tension as measured by the tonometer with the increasing years of the patients examined.

Thus, taking the first reading of the tonometer/

tonometer in each case, and taking only those of my control cases who had normal eyes, or eyes with only a low ( $<2D$ ) refractive error, I have found as follows:-

Age.	No. of eyes examined.	Average Pressure.
20-29	9	16.61
30-39	10	20
40-49	14	17.35
50-59	8	19.12
60-69	6	17.16

(Details of these cases are given in appendix, No.II. p143).

I do not lay much stress on these figures, as the numbers are too small. But so far as they go they tend to show that any hardening of the sclerotic with increasing years does not extend to the cornea, or if it does, does not affect its "indentability" by the rod of Schiötz's tonometer. Marple (4) confirms this observation. He says that a rigid sclera gives the impression of increased tension to the fingers, but that this is not corroborated by the tonometer.

We may conclude then, that in Schiötz's tonometer the errors to which impression tonometers are subject have been as nearly as possible eliminated.

Practical/



Practical points in tonometry.

In the course of my work during the last five months - October 1911 to February 1912 - with the tonometer, I have been led to make the following observations, which may be worth recording.

(1) The tonometer must be applied to the centre of the cornea. To attain this end, the patient must lie in the supine position, with no pillow, or only a very low one, and must fix his eyes on a point on the ceiling immediately overhead. The application of the instrument of course obscures the vision of the eye which is being examined, and care must be taken that the observer's hands do not come between the other eye and the point the patient is fixing, otherwise he is very apt to move his eyes about.

In the case of those whose vision in the other eye is imperfect, an object may be held by an assistant close enough for him to fix. Where the second eye is blind, or where the patient has only one eye, it is often difficult to get him to keep his eye fixed in the required direction, but a little perseverance and encouragement of the patient will generally lead to success. In small children, however (e.g., in cases of buphthalmos) it is often impossible/



impossible to obtain a reliable reading without the use of a general anaesthetic.

(2) It is obviously impossible for the observer to keep his eyes both on the patient's eye and on the scale of the instrument. Fortunately, however, there is a phenomenon which, as a rule, enables him when looking at the scale to be certain that the eye is still in correct position - I refer to the pulsation of the lever. This pulsation is present in almost every examination, though in glaucomatous eyes it may be very slight or be absent. It varies in extent, sometimes being almost imperceptible, but never, so far as I have seen, does the lever swing through more than two of the millimetre divisions on the scale. The mid-point of the swing is taken as the reading.

The observer accordingly waits till the eye is in correct position, applies the instrument to the cornea, and then glances quickly at the scale. If he sees this pulsation of the lever, he takes the reading. If not, he glances down and probably finds that the eye has moved, so that the instrument no longer rests entirely on the cornea, and another attempt must be made to get the patient to keep his eyes in the proper position.

So/

So far as I know, no one has yet definitely proved to what this pulsation is due. Krämer (5) states that, after repeated trials, he has recognized that the pulsation is really that of the observer's radial artery, communicated through the collar of the instrument to the lever. Gilbert (6), on the other hand, thinks the pulsations are due to the patient, and are synchronous with his pulse. He bases this chiefly on the rapidity of the pulse after venesection — this rapidity being shared by the pulsations of the lever.

I attempted to prove, or disprove, this, by feeling my own pulse and watching the lever while another observer felt the patient's pulse and watched the lever, but the pulses were nearly at the same rate, and it was impossible to say definitely which of them was synchronous with the pulsation of the lever.

By a simple experiment, however, I was able definitely to prove that the pulsations of the lever correspond to the patient's, and not to the observer's pulse. I procured a stand with a vertical sliding rod, to which a horizontal bar was attached. To the horizontal bar a test-tube holder was lashed, and the collar of the tonometer was fixed in the jaws of/  
 of/

of the test-tube holder. I was thus able to raise or lower the tonometer, held vertically, at will.

A patient placed on the table had his eye anaesthetized by holocaine. The apparatus was then adjusted so that the tonometer was vertically above the patient's eye. The vertical sliding rod was then lowered, until the tonometer was resting on the patient's cornea, and was fixed in that position.

I was thus able absolutely to exclude the observer's pulse, as his place was taken by this mechanical contrivance, with which, after the adjustments were made, he was no longer in contact. Pulsations of the tonometer lever, however, appeared as usual, and it was easy to observe that they were synchronous with the beat of the patient's carotid artery.

Another way in which movement of the eye is shown is by a sudden movement of the lever through several mm. on the scale. This always means that the eye has moved so that part at least of the foot-plate of the instrument now rests on the conjunctiva covering the sclerotic. This being a much laxer tissue than the cornea, and its curvature differing from that of the cornea, it is easy to see that the tonometer/

tonometer cannot furnish correct readings in this position.

(3) The instrument must be held as nearly as possible vertically. If it is tilted to one or other side its foot does not rest properly on the cornea; and besides, the friction between the rod and the collar is immensely increased and vitiates the readings. Thanks however to the friction wheels referred to already, slight deviations from the vertical do not matter.

(4) In eyes with a small palpebral aperture, it may be necessary that the foot-plate of the instrument should be underneath the upper lid. If care is taken that the lid does not touch the instrument, no error is caused by this manoeuvre.

(5) Schiötz originally advised (7) that ether or alcohol should be used to clean the instrument after use. He now (3) advises against this procedure, from the risk of ulceration of the cornea from the fluid accidentally coming in contact with the cornea.

If, however, sulphuric ether is used, this evaporates so quickly that if a minute is allowed to elapse between the cleansing of the instrument and/

and its application to a patient's eye, there can be no danger, at ordinary room temperatures, of any ether being still unevaporated.

It is well, though, to satisfy oneself by a glance through the tube of the instrument, in which the rod works, that no ether is lurking there. If any doubt is felt, it can be passed through a spirit flame to make certain.

(6) Many observers advise confirming the readings by using the next higher weight. This I believe to be quite unnecessary if pulsation of the lever, as noted above, is seen. Readings taken in these circumstances are invariably in my experience confirmed if the higher weight is used.

(7) Another important point in using the instrument is that the weights must always be fastened to the rod with their weight-mark uppermost. This is the natural thing to do; but a weight may quite easily be picked up and applied upside-down. When so used the weight itself touches the lower arm of the lever, whereas only the top of the rod should do so, and a false reading is given. To prevent mistakes of this kind, there is furnished with the instrument a solid plate whose upper surface is curved/



curved so that if the instrument is placed on it with any of the weights attached the lever goes to the zero mark. If this is done before taking an eye reading, mistakes of this nature are prevented.

This plate would also be useful in the event of the lever getting bent, as it would enable one to tell when it had been brought back to the correct alignment.

(8) I have found it a great convenience to have the values in mm. Hg. for each reading of the instrument written out in tabular form. One is thus enabled to record one's results at once in mm. Hg., instead of merely noting the readings of the instrument and laboriously working them out afterwards from the chart.

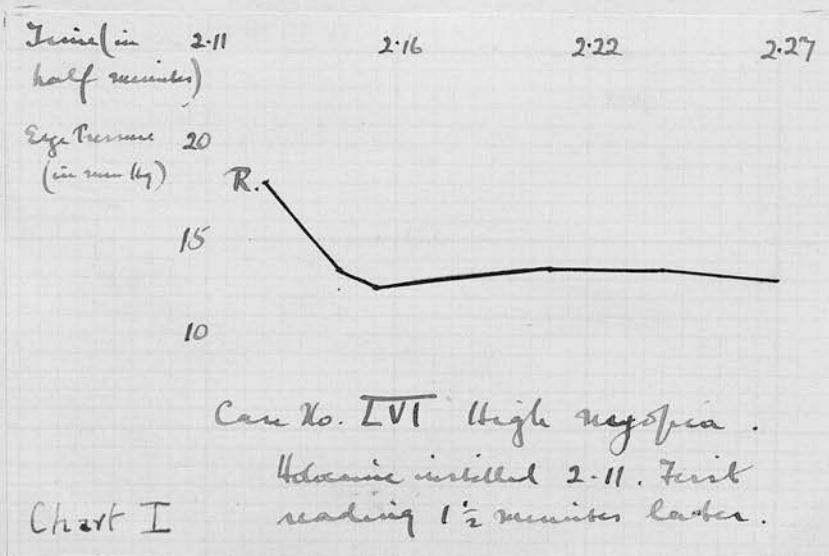
The values for each mm. of the scale may be written out for the 5.5 weight. In the case of the heavier weights, only the values up to 4 mm. of the scale need be recorded, as it is only readings between 2 and 4 mm. which Schiötz considers sufficiently accurate.

(9) Incidentally, the tonometer is valuable in directing attention to the size of the cornea.  
Its/



Its base being 9 mm. in diameter, the observer grows accustomed to the ring of 1 mm. of cornea uncovered by the tonometer in eyes of normal size; and any departure from this is at once obvious.

(10) In normal eyes I have found that the pressure steadily diminishes under tonometric examination. If three or four successive readings are taken at intervals of  $\frac{1}{2}$  to 1 minute or so, the first will be the highest, and the fourth as a rule will be the lowest. Ordinarily this diminution does not go on indefinitely - 2 to 6 mm. fall being a common limit. To a certain extent, it varies with the length of time during which the instrument rests on the eye, but it occurs even when the observer is practised in the use of the instrument, and only requires a second or two to take the reading. Charts, illustrating this phenomenon, are appended.



Time (in 10 P.m. 10.1 10.2 10.2½ 10.3 10.4 10.5 10.6 10.7 10.8 10.9 10.10 10.11 1

quarter  
minutes)

Eye Pressure  
(in mm. Hg.)

10.

5



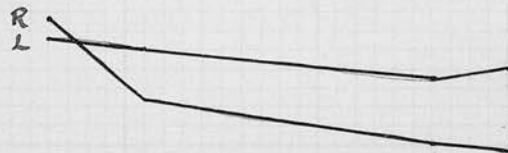
Case No. LXX. Holocaine was instilled at 10 P.m. The first  
Chart II reading was taken 1½ minutes later

Time (in 3.39 3.49 3.59 4.9  
minutes)

Time (in 3.39 3.44 3.49 3.54  
half minutes)

Eye Pressure 15  
(in mm. Hg.)

10



Case No. LXXIII. The tonometer was  
kept on the right eye for one  
minute in an attempt to solve  
the problem of the origin of the  
pulsations of the lens. The  
resulting diminution of tension  
is striking.

Chart III

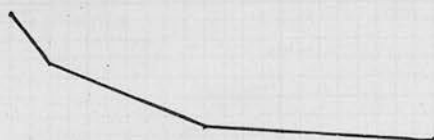
Time (in 7.52 7.53 7.54 7.55 7.56 7.57 7.58 7.59 8.0  
 quarter-  
 minutes)

24

Eye Pressure 20  
 (in mm Hg)

15

10



Case No. XLVII Holocaine was instilled at 7.52  
 The first reading was taken  $1\frac{1}{2}$   
 Chart IV minutes later.

Time (in 2.48 2.53 2.58 3.3  
 half minutes)

Eye Pressure 20  
 (in mm Hg)

15

10



Case No. LXII Double optic  
 neuritis. Holocaine instilled 2.48.  
 B.P. in this case was 116 at 2.48  
 118 at 2.54

Chart V

Time (in 1.8 1.9 1.10 1.11 1.12 1.13 1.14 1.15 1.16  
 quarter minutes)

Eye Pressure 20  
 (in mm Hg)

15

Right  
Left.

Chart VI Case No. LV Transient Exotropia.

In glaucoma cases, on the other hand, the pressure often rises instead of falling during examination, sometimes remains stationary, and sometimes falls. In the latter case, the fall as a rule is a small one. The explanation of the phenomenon in the normal eye probably is that the weight of the tonometer drives some fluid out of the eye, and so reduces its tension; while in the glaucomatous eye the out-flow channels are largely blocked, and this escape does not take place, or takes place much more slowly.

Why an increased pressure should often take place, however, is not so easily explained. We may have perhaps to wait for an explanation until we understand glaucoma itself. If we adopt for the moment, "without prejudice", to use the legal phrase, the increased secretion theory of glaucoma, it may be that the weight of the instrument sets up a reflex stimulation of the secreting cells.

The behaviour of glaucomatous eyes under the tonometer I consider a point of great importance. When the initial pressure is high, but sinks rapidly under tonometric examination, I consider the eye in a much less serious condition than an eye with a similar initial reading, in which the pressure either rises or sinks very /

very slowly.

In the light of the above-mentioned facts, I consider it advisable in every examination to take three or four readings and to record the results. When the ordinary fall has been observed, the first and last readings only need be recorded. Thus 23-17 would mean that the first reading was 23, and the last 17. Where this fall has not taken place, or there has been an intermediate rise, the various readings should be recorded in succession, e.g., 45-48-43, or 45-45 where no fall has taken place. Where readings are not given in this way, in my lists of cases it is to be understood either that the normal fall took place, or that for some reason or other I had to be content with a single reading.

In comparing results, of course, it is necessary to take a fixed figure, and this I have taken as the first reading in every case. To take the mean of three readings, as is sometimes advised, would mislead.

A recent paper by Dr. Polak van Gelder (9) refers to this diminution of tension under tonometry. The value of the paper is discounted to some extent by the fact that the writer has used Schiötz's chart No./



No. I., apparently in ignorance of the alteration which Schiötz has since made (vide infra) in the value in mm. Hg. to be attached to the different readings of the tonometer.

In one of his cases (a boy of 11), the tension fell from 24.5 to 21.5 during 10 applications of the tonometer in rapid succession. On waiting for one minute, the tension had risen to 27.5. Nine rapid applications of the tonometer brought it down to 21.5, after half a minute it had risen to 22.5. Six applications reduced it to 20, one minute's wait raised the tension to 24.5 (its original height); nine applications reducing it this time to 17.5. After two minutes wait, a reading of 21.5 was obtained. Five minutes later the original reading of 24.5 was got. In another case (a man of 59), a pressure of 24.5 reduced by tonometry to 22.5 had risen to its original figure after one minute's wait. I have seldom seen a case in which this return to the first reading occurred, and I consider such cases quite abnormal.

In other cases which he quotes, his experience coincides more nearly with mine - the first pressure taken being the highest, and not being again reached/



reached in the course of observation, even where intervals of one, two, or more minutes are allowed to elapse between applications of the tonometer.

(11) The anaesthetic I have used throughout is that recommended by Schiötz, viz., 2% holocaine. This causes considerable smarting in some eyes, but has the advantage over cocaine that it does not dilate the pupil.

#### Results of Tonometric observations.

As the result of experiments on normal eyes Schiötz fixes the limits of normal pressure as those which give readings of 3 to 6 mm. with the 5.5 g. weight. In the curves which he first published in 1905 (7), this was equivalent to 31 to 24 mm. Hg., but subsequently (8) he found that these figures were too high, and that the true equivalents for these readings of the tonometer were 25 to 15.5 mm. Hg. These are the readings which are given on the chart (marked II.), now furnished with his tonometer. Other observers working with his tonometer and his second chart have come to very similar conclusions.

Langenhan (10) gives his results on 60 normal eyes as 27.5 to 18 mm. Hg., 21 being the commonest figure.

Stock/

Stock (11) in 100 normal eyes found 26 to 12 as the limits.

Marple (12) found 24 to 13, the average being 19.5.

Hans Oeding (13), in 122 normal eyes 27 to 13.5. In two cases 29 mm.

My results in normal eyes.

My observations were not made with a view to determining this question, and many of the 180 eyes examined by me were not normal. But excluding all eyes, whether glaucomatous or not, in my series of primary glaucoma cases, and excluding all abnormal eyes in my control cases, I find I have examined 48 normal eyes. The pressure in these cases varied between 25 and 12 mm. Hg., the average being 18.08 mm. Hg.

Cases in my 'control' series with eye pressures above Schiötz's normal limit of 25 mm. Hg.

In 121 eyes examined in my series of control cases, I have found in eleven of them a tension above Schiötz's limit of 25 mm. Hg. Notes of these cases are given in an appendix (Appendix, IV, p. 146.) I may here briefly summarize them.

Of the eleven, four were cases of secondary glaucoma; /

glaucoma; three were cases of iritis; while one case with detachment of retina and another with dislocation of the lens should probably be classed as secondary glaucoma.

There remain two cases. One (Case No. III.) in a cataractous eye in which swelling of the lens may have produced a tendency to high pressure - secondary glaucoma due to cataract being a well-known clinical entity. It should be noted that the pressures fell rapidly under successive applications of the tonometer. This is a point to which, as I have already said, I have come to attach great clinical importance.

The other case (No. XXVIII.) is a very interesting one, especially in regard to the question of the part which venous stasis and oedema play in the aetiology of glaucoma. The patient, a woman of 54, was dropsical, suffering from heart disease and albuminuria. She had hypermetropic astigmatism (+4), and poor central vision in each eye. The pressure in each eye was 34 mm. Hg. I regret that I was unable, because of the patient's condition, to complete my examination of the case. It should be noted here also that under tonometry the high pressure rapidly fell from 34 to 26, but even the latter figure is above normal.

The/

The analysis of these cases does not shake one's faith in the soundness of the dictum of Schiötz, that any case which gives with his tonometer a reading of over 25 mm. Hg. should be viewed with the gravest suspicion. It may well be that the cases of cataract occasionally seen, which after a perfectly performed operation, and with clear media, do not obtain 6/6 vision with any glass, may be cases in which a slight rise of tension (undetectable by the fingers and giving rise to no subjective symptoms), has been present during the ripening of the cataract. In view of this possibility it would be advisable, wherever practicable, to take the tension of such patients from time to time. If a tension above normal is found, miotics might be used, or in the event of their failing to reduce the tension, preliminary iridectomy might be done.

The use of the tonometer is so simple, so rapid, and so safe, that its systematic employment would take up little of the observer's time, and might well repay him by its findings.

Cases in eyes unoperated on in both my series, with eye pressures below Schiötz's normal limit of 15.5 mm. Hg.

Turning now to the question of hypotony,

I/



I find I have examined no fewer than 18 cases in my two series (excluding all eyes that had been operated on), in which I found tensions below Schiötz's limit of 15.5. These cases are given in detail in the Appendix V. (p. 148) They may be here summarized.

Seven of them were cases of myopia of varying degree (three of them complicated with choroiditis and one with cataract); two others were cataract cases; one a case of choroiditis; one of detachment of the retina in a hypermetropic eye (+2); one a hypermetropia of +1D; four had disease in the other eye (1 sarcoma, 1 glaucoma, 1 retro-bulbar neuritis, 1 iritis); the remaining two were in patients with good vision suffering from chronic disease (one gastric, the other tubercular spinal trouble).

In view of these last two cases especially, both of whom had 6/6 vision and good fields, I am inclined to think that Schiötz's lower limit of 15.5 is too high. It is certainly possible to get apparently perfect vision in an eye in which the tension may be even at times below 12 mm. If with Stock (loc.cit.) we take 12 mm. as the lower limit in normal eyes, only three of the cases examined were below it, viz., Case X., high myopia and cataract, Case/



Case XLIII. myopia and choroiditis, Case LIV., with perfect vision, but a sarcoma in the other eye.

Myopia. The association of myopia with low tension has been denied by Marple (loc.cit.) but my observations tend the other way. A glance at the table of my myopia cases (Appendix, No. III, p. 145), will show that their general level of eye pressure was much below normal.

#### Eye Pressures in Glaucoma.

In only one case recorded so far (14), since the tonometer came into use, has glaucoma been seen with a tension within the normal limits. This case of Stock's with typical glaucoma had pressures in one eye of 22, and in the other of 25. He concludes that these pressures, though apparently normal, must have been high for the individual.

The pressures in my cases are given in detail in the Table (Vide p. 74 *infra*), and need not be quoted here.

Some of the facts are worth noting.

(1) In no case of glaucoma unoperated on and untreated with miotics did I find a pressure of less than 30 mm. Hg. This coincides with the experience of most observers. The cases formerly spoken/

spoken of as "Excavation without increased tension" no longer exist. The tonometer has proved that in all such cases (with the one exception referred to above) there is a real increase of tension, though this may be quite undetectable by the fingers.

(2) The beneficial action of miotics was well shown by the tonometer in the following cases.

Glaucoma Case No. XV. Eye Pressure of 30-27 fell to 23-21 (other was  $14\frac{1}{2}$ ).

Case No. XXI. Eye Pressure of 40-36 fell to 26.

Case No. XXV. 65 fell 39.

Case No. XXXI. 33-30 fell to 21-18 under pilocarpine t.i.d.; when this was reduced to once daily, the pressure rose to 32-22.

Pressures of 100 or over were got in four cases, viz., Nos. I., II., VII., XIX.

In eyes blind from glaucoma, and never operated on, the following pressures were got:- 104, 102, 89, 89, 82, 74, 71, 54, 45, 30 (Case VIII.).

The tonometer as a test of the efficacy of operations.

One very special value of the tonometer is in testing the results of operation. To make any statistics of comparison between different operations, very much larger numbers of cases must be examined than I have had the opportunity of testing, but in

28 cases I had the opportunity of studying with the tonometer the effect upon tension of some or other operation for primary glaucoma. In 18 the pressures tested at varying periods from two weeks to fifteen months after operation were within normal limits.

Hypotony after operation for glaucoma.

Three had very low tensions. One of these with a tension of 4 mm. Hg., was examined only two weeks after operation and would probably, like other similar cases I had opportunities of re-testing, rise to a normal figure later on. Two others were seen ten and nine months respectively after operation, and had tensions below 4 mm. Hg. In both cases the eye was somewhat irritable, but in neither had there been any deterioration of vision, or any detachment of the retina since the operation. Both were trephine cases in which a large iridectomy had been done at the operation.

Cases in which eye pressure after operation remained above normal limits.

In seven cases the eyes were above normal limits. In four of these the pressures were 30 or under. One of these with very limited vision was no worse 14 months after operation; another, 10 months after/

after operation, was very slightly worse; the third was blind to start with; the operation had been undertaken to relieve pain, and had been perfectly successful from that point of view. The fourth, an acute glaucoma, 5 weeks after operation, had improved.

In the three other cases, the pressure was over 30. One of these was blind to start with, one had developed cataract and V.A. could not be tested, while no reliable data were available concerning the state of the third prior to operation.

Variability of tension in glaucomatous eyes.

In considering these figures, it is important to bear in mind that, while in normal eyes there is little or no variation in pressure at different times of day, in glaucomatous eyes there may be great variations. Maslenikow (15), using Maklakow's tonometer, found the tension in glaucoma always higher, sometimes by as much as 23 mm., in the morning than at night.

Schiötz (3) also reports a case in which iridectomy had been done for chronic glaucoma. Some weeks later the eye was very soft (3 mm.), but next day it was 40 mm. The patient stated that his eye often felt very soft at one time of the day and hard/

hard at another.

V. Grönholm (16.), in an interesting study on the effect of the size of the pupil, accommodation and convergence on the tension, reports a case in which the tension fell from 37 to 28 as the result of miosis and accommodation, from reading with the face to the window in a good light for three quarters of an hour. The same patient then sat in the dark for three quarters of an hour, and the eye pressure went up to 65.

Other values of the tonometer.

As it may be taken as almost an invariable rule that a glaucomatous eye (untreated) has a pressure of 30 mm. Hg. or over, the tonometer furnishes us with a ready means of differentiating between those cases of optic atrophy in which the condition is primary, and those in which the atrophy is secondary to glaucoma.

Its value in giving an exact reading of the tension is one that all ophthalmic surgeons will find invaluable. "Is or is not that tension raised?" is a question every ophthalmologist has asked himself again and again. To the conscientious man the difficulty of deciding this essential point has been often most/



most disquieting. In this connection, one of my control cases (No. 39) is instructive. This patient had a tendency to secondary glaucoma in an eye which had been operated on many years before for congenital cataract. One day there was a sudden flare-up, and when the pressure was taken it was found to be 70 mm. Hg.. Under treatment this condition subsided entirely in the course of a few days, and the patient was able to resume his work. Some days later he again complained of some discomfort in the eye. The fingers gave an uncertain judgment; but fears were allayed of its being a recurrence of the glaucomatous condition, by the tonometer, which gave a reading of 21 mm. in both eyes.

Another point in which its help is invaluable is in deciding the difficult question whether or not to operate. There is perhaps no better known name in connection with glaucoma than that of Bjerrum, and his recognition of the angular scotomata radiating from the blind spot and of the step-like limitations of the nasal field are everywhere recognised as of the highest importance. Yet it is on the judgment of the tonometer of Schiötz that he relies in simple glaucoma. If miotics reduce the tension/

tension to normal and keep it there, he does not operate. But if they fail to do so, however good the central vision and the fields may be, he operates (17.).

#### Unreliability of the fingers.

As showing the unreliability of the fingers in estimating tension, a case of Stock's (11.) is of interest. In this patient several experienced observers failed to detect raised tension, but the tonometer actually gave a reading of 70 mm.

Marple ( 4 ) says that even with the 'tactus eruditus' tension is not recognised as elevated, unless it is over 35 mm. or as diminished, unless it is as low as 10 mm. It is just in those cases where the tension is between 35 and 25 that the importance of deciding whether plus tension is present or not is so great. In these cases the tonometer gives us a ready and a reliable answer.

But I need not labour the point further. The fact that in my reading I have come across very numerous references in praise of Schiötz's tonometer, and have heard of no one who has once learnt to use it discarding it or speaking adversely of it, is sufficient testimony to its value.

#### Sensitiveness/

Sensitiveness of the tonometer.

In the special point to which my research has been directed, it is important not only to be able to record gross changes in tension, but also to follow the slightest variations in tension. Schiötz's tonometer amply fulfils these conditions. The harder the eye-ball, of course, the greater must be the increase of weight to indent it, so that, as Schiötz's chart shows, in the higher pressures a difference of 1 mm. scale reading may represent a difference of as much as 14 mm. Hg., e.g., taking the 15 g. weight, a reading of 2mm. represents 96 mm. Hg., while a reading of 3 mm. means 82 mm. Hg.

But in the lower pressures each division on the scale means a much smaller difference in mm. Hg. Thus, using the 5.5 weight, a scale reading of 2 represents 30 mm. Hg., and one of 3, 25 mm., while with the same weight a reading of 8 represents 12 mm. Hg., and one of 9, 10 mm. Hg. - a difference of only 2 mm. Hg. for 1 mm. of the scale.

Accordingly we must not lay too much stress on differences of a few mm. Hg. when we are dealing with the higher pressures - if the eye can recognize differences of a quarter mm. on the scale it is as much as we can fairly ask of it. But in the lower pressures slight differences of tension are readily detected, and no doubt need be felt (provided the various points referred to above are attended to) as to their accuracy.

## P A R T    I I.

---

### THE BLOOD PRESSURE and its MEASUREMENT.

---

It is outwith my purpose to enter here into an exhaustive study of the general subject of blood-pressure. But in order to estimate the value of the experiments of myself and others undertaken with a view to determining what relations exist between the blood-pressure and the intra-ocular pressure, especially in relation to glaucoma, it is necessary to study the methods that have been used in these experiments and to determine their value.

Historical. Blood-pressure measurements may be said to have begun with Poisseuille's invention of the mercurial manometer in 1828 and Ludwig's invention of the kymographion in 1847. The first attempt to measure blood-pressure clinically was Vierordt's in 1855 - a year before von Graefe's first iridectomy for glaucoma.

#### POTAIN'S SPHYGMOMANOMETER.

The first instrument, however, of clinical value and free from gross inaccuracy was von Basch's sphygmomanometer invented in 1876. As improved by Potain in 1889 it has had, and still has in France, a wide vogue, and as we shall see was the instrument employed /

---

NOTE. The historical data in this section where no references are appended are taken from Janeway's Clinical Study of Blood Pressure 1910. This book gives an excellent historical & critical summary of the evolution of the Sphygmomanometer.



employed in two of the early investigations of blood-pressure in glaucoma; namely, those by Terson and Campos (18) in 1898, and by Joseph (19) in 1904. Potain's apparatus consists essentially of a pelotte blown up with air which is applied to a superficial artery (temporal or radial). The pelotte is pressed against the artery - the subjacent bone giving the counter resistance - until the distal pulse ceases. The pressure inside the pelotte at this point is measured by a spring (standardized previously against a mercury manometer) and is registered on a dial. A full description of the instrument is given in Janeway (loc.cit.)

The apparatus is portable and convenient but unfortunately quite unreliable in comparative work. One reason will suffice:-

The tissues surrounding the arteries vary in different people and in different arteries in the same person.

V.Basch admits that with his instrument the radial artery requires as a rule 20 mm. and may even require 60 mm. more pressure to obliterate it than the temporal. And in his book on the subject Potain tells of a young girl in whose radial his instrument gave a reading of 165 mm., while the temporal was only 55 mm! He also states that there may be a difference between the two radials of 20 mm.

These/



These observations made by the inventors of the instrument themselves are sufficient to condemn it utterly for our purpose. For we know by long established and undisputed physiological investigations that the pressures in all the larger arteries are practically identical. The instrument may have a certain value when the same artery of any one individual is examined at different times; but for comparative observations on different people it has no scientific or practical value whatsoever.

#### GARTNER'S TONOMETER.

---

Another instrument used in similar investigations (Kramer 20) in 1910, is that of Gärtner, 1899, which he calls a tonometer. In this instrument the pressure of one of the digital arteries is measured. The finger is rendered bloodless by a strong rubber ring which is fitted on to the tip of the finger and rolled upwards until the two distal phalanges are bloodless. A small cuff similar to the Riva Rocci armlet (vide infra) is put round the finger above the ring and is blown up to a pressure sufficiently high to maintain the action of the ring which is then removed. The air in the cuff, which is connected with a manometer, is then gradually allowed to escape until the pressure is low enough for the blood to return to the finger. This point is readily observable as the finger suddenly flushes.

Martin/

Martin has shown that to get accurate results with this instrument the ring must be placed exactly on the middle phalanx. He attributes the results of many of the critics of the instrument who have found variations in simultaneous readings from different fingers to this technical error.

Another point in which Gärtner's instrument is inferior to that of Riva Rocci is that the digital arteries are notoriously subject to vaso-motor change as the result of cold, etc.

With these limitations the instrument is of undoubted value and Krämer's researches, if perhaps not carrying the same weight as those undertaken with the Riva Rocci apparatus, are certainly not to be lightly set aside.

#### LAULANIE'S SPHYGMOMANOMETER.

---

Frenkel (21) in his researches in 1906 on Blood Pressure and Intra-ocular Pressure used Laulanie's apparatus. Frenkel describes this as a bivalve metal bracelet worked by a screw and having in its interior a pelotte of rubber filled with water intended to transmit the pressure of the vessels. This reservoir is connected by a rubber tube filled with water to a mercurial manometer, which is arranged so as to record the readings on a travelling tambour/

tambour. The bracelet is fixed round the fore-arm. I have not been able to obtain any other description of this instrument than this short statement by Frenkel, and so am not in a position to criticise the value of his readings. If the pelotte he used was of sufficient breadth (he makes no statement on this point and no reference to v.Recklinghausen's work) (vide infra) there seems no inherent reason why the apparatus should not give good results.

I have not been able either to obtain the paper published by Laquiez (a pupil of Frenkel's) in 1907 on the same subject as Frenkel's in 1906. Presumably he used the same apparatus.

#### RIVA ROCCI'S SPHYGMOMANOMETER.

---

The last apparatus which it is necessary to mention is that of Riva Rocci invented in 1896. This instrument is so widely known that description is hardly necessary. The new principle in the instrument is that the artery is obliterated by means of a bag encircling the arm, just as the tourniquet is used in surgery. The bag which is surrounded externally by a non-elastic backing is blown up with air until the pulse is obliterated. The bag is in direct communication with a mercurial manometer which registers the exact/

exact pressure in the bag at any given moment.

#### V. RECKLINGHAUSEN'S MODIFICATION.

---

In 1901 v.Recklinghausen published an important study on the effects which varying width of the encircling bag produced on the results given by the Riva Rocci apparatus. Into his experiments we need not enter. Suffice it to say that he proved that the original Riva Rocci with its cuff of at most 5 cm. width was inaccurate, and that to give accurate results a cuff of 10 or 12 cm. width was essential.

This discovery invalidates the researches on blood-pressure in glaucoma made by Bajardi (22) in 1900, as they were made with the narrow cuff of the original Riva Rocci apparatus.

Kümmell in 1911 (23) in a similar research used the modified Riva Rocci, and it is the instrument which I have employed in my work on the same subject.

#### VALIDITY of the RIVA ROCCI READINGS.

---

Observers are agreed that the readings given by the Riva Rocci apparatus are not influenced by the condition of the tissues of the arm, provided it is not (1) oedematous, (2) excessively adipose, or (3) in a state of muscular rigidity. A sufficient proof of this fact is that readings taken over clothing/

clothing, when this is moderate in amount, do not differ appreciably from those taken with the bare arm.

The question of the influence which the condition of the artery wall may have on the readings is, however, a disputed point and one which cannot as yet be considered settled.

One set of observers consider that it is quite a negligible factor. Janeway, (*loc.cit.*p.60 ) is the most pronounced of modern writers in this direction. His conclusions are based on experiments made by v.Basch who estimated that a normal artery when empty required only 1 mm. pressure to obliterate it and a sclerotic artery only about 5 mm.

Against this statement may be placed the work of Herringham and Womack on arteries removed from the body (24). In 49 cases they found the pressures required to obliterate the lumen varied from 4 to 34 mm. - only two, however, of their readings were above 24 mm. Gibson (25) in similar experiments found 15 mm. as his highest figure. Leonard Hill (26) states that there is no proof from physiological research that more than 30 mm. Hg. is ever necessary to obliterate an artery.

The fact, however, that it must be admitted if these experiments are valid, that at least 30 mm. of the reading given by the Riva Rocci apparatus may in/



in some cases be due to the resistance of the vessel wall, is a serious point for those who contend that its readings are those of the actual blood-pressure.

Russell (27) has done valuable service in proving that a large part of a thickened artery may be muscular (not fibrous tissue as was previously held); and therefore, that such an artery retains the power of contractility. He maintains on clinical and experimental grounds that the vessel wall may have a much higher share in a Riva Rocci reading than even the 30 mm. of Hg. which is the highest that Gibson and others would consider possible. The blood-pressure may rise 20 mm. as the result of violent exercise and this he maintains (28.) is the limit of reserve power of the normal average heart. Riva Rocci readings, therefore, which rise more than 20 mm. above the normal limits must represent something else than a genuine rise in blood pressure - that "something else" being the resistance of the vessel wall.

Williamson (29) found in Marathon runners a rise of 30 to 40 mm. after a practice run, and concludes with Russell, though going slightly beyond his figures, that this probably represents the limits of the heart's reserve power and that higher readings of the sphygmomanometer above the normal must be due to the vessel wall.

Leonard Hill, however, (26) says that the normal/

normal pressure may be doubled by active exercise. In students after running up and down stairs he has found pressures up to 200 mm.Hg.

In support of Russell there are such authorities as Campbell (30) and Oliver (31). The latter bases his agreement with Russell on the fact. that in arterio-sclerosis the armlet may give different readings in the two arms or two forearms, or in the arm and forearm of one side, such differences being in opposition to our physiological knowledge.

In another work Oliver (32.) adduces the readings of his haemodynamometer to prove this point. This instrument works on the principle of balancing the blood-pressure wave instead of obliterating it. With healthy arteries it gives readings identical with those of the armlet. In arterio-sclerosis its readings are often much lower. In a table of high pressure cases which he gives (33) there is an average difference between the armlet readings and those of this instrument of 50 mm.Hg. He concludes that the armlet method in arterio-sclerosis may give a figure as much as 100 mm. above the real blood-pressure, the resistance due to the thickened hypertonic vessel wall being the cause of the error.

With/

With such a conflict of evidence and of belief and with so eminent and capable men on both sides, it would be premature to attempt to draw conclusions and the question must be left as unsettled. That Janeway is right is unlikely. The artery wall almost certainly is not a negligible factor. But time and further experiment alone will declare whether it is a factor of quite minor importance as Gibson and others would have it; or whether Russell is right in maintaining that where the arteries are thickened they may play a very large part indeed in making up the Sphygmomanometer reading; and that, therefore, the instrument though invaluable on other grounds is useless as a criterion of the actual blood-pressure.

We have seen reason to believe that in attempting to estimate the relationship of the blood and the intra-ocular pressures, we have in Schiötz's tonometer a dependable instrument for measuring the latter clinically.

With regard to the blood-pressure there can be no doubt that the Riva Rocci Sphygmomanometer is free from defects inherent in previous types of apparatus and is - in one or other of its numerous modifications - the best means we have of estimating the blood/

blood pressure clinically. But at the same time there are grave doubts as to whether the readings which it gives are not affected so much by the condition of the vessel wall as to be unreliable as estimates of the real blood pressure.



P A R T    I I I .

---

THE RELATION OF BLOOD PRESSURE TO INTRA-  
OCULAR PRESSURE.

---

Blood pressure a factor in intra-ocular pressure.

That the blood pressure is a factor in the maintenance of the intra-ocular pressure has been proved experimentally in animals.

Henderson and Starling (34) inserted a canula into the left carotid of a dog, and connected its right eye with a manometer ingeniously constructed to prevent fluid entering or leaving the eye through the manometer needle. They then tied the subclavian and vertebral arteries on the left side, and recorded the pressures in the right eye and in the left carotid artery. The abdominal aorta was now occluded. The result was a rise in the blood pressure in the neck from 123, to 153,, and in the eye pressure from 26 to 34. The right vertebral and subclavian were then tied, with the result that eye and blood pressure rose still higher. On loosening the ligatures round the latter two vessels, and again on loosening that round the aorta, there was/



was a fall in blood pressure, and a simultaneous fall in eye pressure.

In another experiment they tied the arteries in the neck on both sides, with the result that the eye pressure fell, though the blood pressure rose.

It is to be noted, however, that though the blood pressure in the ophthalmic artery in this latter case was presumably zero, as there was no blood reaching it from the heart, the eye pressure did not fall to zero, but remained at 9 mm.

This confirms observations made after death, when it has been found that, though the blood pressure falls to zero when the heart stops beating, the eye pressure does not do so, for some considerable time.

But not the sole factor.

In other words, though the blood pressure is a factor in maintaining the intra-ocular pressure, it is not the sole factor.

This conclusion has been come to by Wessely (35), who found that, on injecting adrenal in into the blood, a rise of blood pressure occurred, but not always a rise in the intra-ocular pressure; the/

the reason being that this latter may be influenced by local vaso-constriction and also by contraction of the muscles of the orbit.

The same experimenter stimulated the cervical sympathetic in a rabbit, and found that this caused a decrease in the intra-ocular pressure (as the result of local vaso-constriction), while the general blood pressure remained unaltered. My observations in the human subject.

These experiments suggested to me the advisability of testing with the tonometer and sphygmomanometer, whether similar results could be obtained in the human subject.

(1) Sudden rise in Blood Pressure, no rise in Eye Pressure.

The experiments were conducted as follows:-  
The patient's blood and intra-ocular pressures were taken as usual in the horizontal position. He was then asked to take exercise (running up and downstairs). On his return, the pressures were immediately taken again.

This experiment was performed on three patients - the following were the results obtained.

(1) Case LIV. P. aet. 32. Normal eye

V./

V. = 6/6. Blood pressure, 112, falling after rest on the table to 100. Eye pressure, 12, falling during same time on tonometry to  $8\frac{1}{2}$ . On returning after exercise, the blood pressure had risen to 130, but the eye pressure was  $7\frac{1}{2}$ .

(2) Case LXIII. P. aet. 22. Left eye normal, V. = 6/6. Blood pressure, 112, falling to 110. Eye pressure  $14\frac{1}{2}$ , second reading 14. After exercise, blood pressure was 132, but on attempting to take eye pressure, it was found that the effect of the holocaine had worn off. Another drop was instilled, and patient sent off for further exercise. On return the blood pressure was again 132. The eye pressure was  $14\frac{1}{2}$  (i.e., its original height - the fact of its having reached this height being attributable to the long time, five or six minutes, which had elapsed between the second and this the third reading).

(3) Case LXV. P. aet. 14. Left eye. Blood pressure, 114. Eye pressure, 18. After exercise, the blood pressure had risen to 140, but the eye pressure had fallen to  $14\frac{1}{2}$ .

These experiments, as will be seen, were all/

all made with young subjects. in whom the vessel walls were normal. No one, so far as I know, denies that the rise in the Riva Rocci reading in such cases, after exercise, represents anything but a genuine rise in blood pressure. Yet in these cases the eye pressure, instead of rising with the rise of blood pressure, continued the fall which has been shown (in Part I.) to be normal.

It is obvious from these experiments that, if there is a rise of intra-ocular pressure as the result of the heightening of blood pressure, it must be in the normal eye purely a momentary heightening. The vaso-motor mechanism of the eye must immediately readjust itself to the altered conditions, perhaps by a local vaso-constriction, and so restore the ocular tension to its previous level.

In this connection another observation should be recorded:- As a rule, I have found that the Riva Rocci reading first taken in the course of an examination is higher than one taken a short time after. On several occasions, however, a rise of pressure was noted during examinations, e.g., Control Cases Nos. III., IV., LXI., where the pressures rose respectively from 152 to 182; from 250 to/

to 270; and from 128 to 138. Yet in all these cases the ordinary fall of eye pressure under tonometry took place.

(2) Changes in Blood Pressure at intervals of days.

Granting then, that in the normal human eye the eye pressure is not altered (unless momentarily) by a sudden increase in the blood pressure, the question arises, whether a general lowering or heightening of blood pressure continuing over a longer time would affect the eye tension. I have had occasional opportunities of examining my control cases at intervals of some days or weeks, and have sometimes found a considerable alteration in the level of the blood pressure on the second occasion.

(a.) Sometimes corresponding change in eye.

As regards the eye pressure, however, my results are inconclusive. In some patients there is a correspondence of the pressures, e.g., Case XX., where I found a pressure in both eyes of  $15\frac{1}{2}$ , with a blood pressure of 208. After three days in Hospital, the blood pressure had fallen to 142, and the eyes to  $12\frac{1}{2}$  and  $13\frac{1}{2}$ .

In Case LII., after a month in Hospital, there was found a lowering of blood pressure of only/



only 5 mm., 130 to 125; but the right eye had gone down from  $19\frac{1}{2}$  to 12. This of course is quite out of proportion to the fall in blood pressure, and almost certainly was not due to it. The eye was highly myopic.

A more plausible case is No. XXXIX., in which the blood pressure was 140 on one occasion, and 122 a fortnight later; the left eye readings on the two occasions being 21 and  $19\cdot2$  respectively.

(b.) Sometimes no corresponding change in eye.

On the other hand, in Case XXXI., a rise of blood pressure took place (112 to 113), but the eye pressure fell ( $14\frac{1}{2}$  to 12). In Case LXI. blood pressure fell (142 to 123), while the pressure in the left eye rose from  $13\frac{1}{2}$  to  $16\frac{3}{2}$ . In Glaucoma Case XV., the blood pressures on two occasions were 160 and 124, but the eye pressure in the non-glaucomatous (left) eye was the same ( $14\frac{1}{2}$ ) both times.

Average Eye Pressure in patients with same Blood Pressure.

I have studied this question in another way. In my series of control cases I have excluded all eyes with pressures above 25 or below 12, and have arranged the patients according to their blood pressures, with the following result:-

\* Blood/

<u>Blood Pressure.</u>	<u>No.of Cases.</u>	<u>No.of Eyes.</u>	<u>Average Eye Pressure.</u>
200 mm. & over.	7	13	18.01
Between 180 & 199	2	4	16.25
" 160 & 179	5	8	17.00
" 140 & 159	15	23	17.47
" 120 & 139	11	20	19.30
" 100 & 119	10	16	16.50
Under 100	1	2	14.50

In this table the patients with blood pressures between 120 and 139 have a higher average of eye pressure than those with much higher blood pressures.

Finally an observation of von Graefe's should be mentioned (36). In cases of cholera it is well known that there is a tremendous lowering of blood pressure. The eye-pressure (of course tested in those days with the finger) did not alter in the cases of this disease which he investigated.

#### CONCLUSIONS.

The result of these investigations is to prove fairly conclusively that, whatever may be the result of experiments on animals, there is little, if anything, to show clinically that changes in the blood pressure in the human subject carry with them any change in the intra-ocular pressure in the normal eye./

P A R T    I V.  

---

THE <sup>^</sup>ROLE OF BLOOD PRESSURE IN THE AETIOLOGY  
OF PRIMARY GLAUCOMA.  

---

Experiments in animals, such as those we have referred to by Henderson and Starling, Wessely, etc., have shown that in the dog and cat, under the somewhat unnatural conditions of the experiment, there was a close similarity between the eye and blood pressure curves. This naturally led ophthalmic surgeons to enquire whether in Glaucoma, in which the heightening of the eye pressure is the essential symptom, there could be shown any corresponding rise in the general blood pressure.

Clinical observations in favour of a connection of high Blood Pressure with Glaucoma.

Some facts have seemed to point to this connection. It is well known, for instance, that excitement, worry, nervous strain, etc. are often noted as preceding an attack of glaucoma. These are conditions in which it is natural to suppose there would be a rise of blood pressure.

In/

In support of this idea we have some clinical observations scattered throughout the interminable literature of glaucoma. Dunn ( 37) for instance, stated in 1908 that in primary glaucoma he has invariably found the blood-pressure above normal. Jackson (38), in 1909, makes a similar observation. Observations of this nature, however, are of little value unless patients not suffering from glaucoma are examined at the same time.

There are, moreover, numerous instances on record in which a lowering of blood pressure has been simultaneous with an amelioration of the glaucomatous symptoms. Fox, Webster and Batroff (39), for example, record a case of acute glaucoma, in which miotics had failed to reduce tension, or to narrow the pupil. The blood pressure was 265. A venesection of twenty ounces was done, the blood pressure fell to 150, and miotics now narrowed the pupil and reduced the ocular tension, permitting an iridectomy to be done.

Roun(40) tells of a patient of 60 whose blood pressure was 210, and whose eye tension was +2. High frequency currents in eight sittings of 10 to 15 minutes each twice weekly, reduced the blood pressure to 140, and the eye tension nearly to normal./

normal.

Mackay of Edinburgh has long taught the value of general or local depletion, (by venesection or leeching), and I have on several occasions in his wards heard patients bear witness to the increased comfort of a painful eye after leeches had been applied to the temple.

A recent paper by Gilbert of Munich (41) emphasizes the value of venesection in glaucoma, and quotes cases in which the eye pressures taken by Schiötz's tonometer and the blood pressure kept remarkably parallel. The maximum effect in reducing both pressures occurred, in simple glaucoma, from 6 to 24 hours, but in inflammatory (sub-acute) glaucoma, 24 to 48 hours after the venesection.

The author, however, admits that the mere withdrawal of blood in the quantity he advised (viz., 3 g. per kg. weight of the patient) is not sufficient to cause the diminution in blood pressure, and suggests that perhaps the result may be due to a reduction in the viscosity of the blood.

Blood Pressure certainly not the only factor in the causation of glaucoma.

That there may be high blood pressure without/



without glaucoma is a fact that has only to be stated to be obvious. The highest blood pressures obtainable are those found in chronic kidney disease, yet the combination of chronic nephritis with glaucoma, though occurring occasionally, is rare.

In order to test whether the high blood pressure in these cases predisposed to glaucoma by effecting some raising of the intra-ocular pressure, Krämer (loc.cit.) examined a series of medical patients suffering from various forms of kidney, heart and blood vessel disease. Many of these patients had blood pressures of 150 and upwards, but in only one case, a patient with arterio-sclerosis, was there a higher eye pressure than the normal, and that patient had glaucoma!

#### Definite attempts to study Blood Pressure in Glaucoms.

##### (1) Terson and Campos

The first to attempt a careful study of the subject were Terson and Campos (18), in 1898. As we have seen, the instrument they employed in their blood pressure investigation, that of Potain, is useless in comparative work, as its readings depend so much on the tissues surrounding the radial artery. Where it gives a low reading, there is not so much objection to it; and we may therefore accept one of their findings which has been conclusively substantiated/

substantiated since, viz., that it is possible to have extreme hypertension in the eye and yet to have only normal blood pressure.

Their suggestion as to the aetiology of acute glaucoma is that it may be a sudden oedema of the eye, like the acute oedemas which occur in the lungs.

(2) Bajardi.

The next to take up this research work was an Italian, Bajardi (22) in 1900, using the Riva Rocci apparatus for his blood pressure measurements. Unfortunately, in his case also, the apparatus used is unsatisfactory, as he used the narrow cuff (vide supra Part II.). Bajardi found high arterial pressure in 50% only of his glaucoma cases. He noticed that there was a tendency to great variations in blood pressure in his glaucoma patients, e.g., after exercise, as the result of emotion, at different times of day, etc. He considers this tendency of much greater importance than the actual height of the blood pressure.

(3) Joseph.

Four years later Joseph (42) investigated 18 cases of glaucoma. He found the blood pressure high/

high in 15 of them, but as he also used Potain's apparatus his results have little value.

(4) Frenkel.

In 1906, Frenkel with the Laulanié instrument, of which we have quoted his description, found high blood pressure in 13 out of 14 cases of glaucoma. He was the first to see the necessity of confirming his results by examining a series of other patients as 'controls'.

Frenkel found a remarkable difference in blood pressure between his glaucoma cases and the cataract cases he used as controls.

(5) Laquiez.

Laquiez, a pupil of Frenkel's, confirmed his observations in the following year, 1907. In each of his 19 cases of glaucoma, he found a high blood pressure. As I have stated, I have not been able to obtain Laquiez's original paper, and have no details as to the methods he employed.

(6) Krämer.

The question was allowed to remain in this stage till 1910, when Krämer once more decided to investigate it. He had read with interest Frenkel's paper on the subject; but was not satisfied that the question/

question had been fully thrashed out.

Two points especially seemed to him to militate against high blood pressure having a causal relation to glaucoma. The first of these was the knowledge that the prodromal attacks of glaucoma are, as a rule, one-sided - sometimes as long an interval as 20 years intervening before the second eye is attacked. This seemed to him incompatible with the theory that high blood pressure was an important causal factor in glaucoma, for we know that the pressure in the arteries supplying the two eyes must be identical, or nearly so. The other point which had struck him was, that in the experiments on animals by Wessely and others, complete parallelism of blood and eye pressure curves was not always obtained. Sometimes a rise of blood pressure was followed by a sinking of eye pressure.

Finally, in reviewing the work of Terson and Campos, Bajardi and Frenkel, he found sufficient discrepancies in their numbers to make him think it rather improbable that a direct or even an indirect connection existed between Blood Pressure and the Eye Pressure in glaucoma.

A direct connection is at once disproved by the fact that in high blood pressure cases seen in/

in the medical wards, glaucoma is of rare occurrence.

The indirect connection, which alone he thought possible, might be (1) that with an existing predisposition to glaucoma, increase of blood pressure might cause an attack, or (2), when once an attack had come on, hinder the return of the eye to normal; or (3), that through the rise of Blood Pressure the disposition to glaucoma might be increased.

The first of these points is supported by the frequency with which, after operation for glaucoma, an attack comes on in the other eye, but negatived by the fact that this attack, as a rule, occurs two to four days after operation, when the excitement of the operation has passed away, and the patient's blood pressure has presumably fallen.

To this point of Krämer's, we may add that another reason can be given for the occurrence of the attack in the second eye. Grönholm (16), already referred to, has shown that the midriasis induced by darkness may send up the pressure in a glaucomatous eye; and he argues that it is the common custom of bandaging both eyes, after an operation for glaucoma in one, that is responsible for these attacks. The second eye, predisposed to glaucoma, has its pressure/



pressure raised by the darkness caused by the bandage.

The second point he answers by the fact that miotics can act in reducing intra-ocular pressure, even when the Blood Pressure is higher than normal. (The case recorded by Fox, Webster and Batroff, vide supra, however, shows that miotics may sometimes fail to act).

The third point is the one which he sets himself to investigate. We have already referred to his tonometric experiments in medical patients with high blood pressures, and the negative results so obtained - the eye pressures being in each case normal.

He proceeded to examine a series of glaucoma cases and a series of controls, as had been done by Frenkel. His results, briefly put, are as follows:- In 45 cases of primary glaucoma an abnormal height of blood pressure was found in 35.6%, while in 90 cases of cataract, 33.3% had increased blood pressure - practically the same percentage as in glaucoma. These cases, he concluded, confirm his opinion that no direct connection between arterial and intra-ocular tension can be proved, and this opinion, he declares, is now shared by Terson. He suggests that/

that future research might be directed towards a study of the arterial pulse often noted in glaucomatous eyes; and also in blood pressure investigations, to the diastolic as well as the systolic pressure, in the hope that this might throw light on the subject.

Krämer's paper is a lucid and valuable contribution to the solution of the question.

Unfortunately the blood pressure apparatus which he used is one which is not free from objection - that namely of Gärtner, modified by Tauber.

Kummell.

To the methods of the latest investigator of this subject (Kummell) (23), no such objection can be taken, as he used the modified Riva Rocci sphygmomanometer.

This observer objected to Krämer's control cases on the ground that their average age was too high - cataract being a disease of a relatively later period of life than glaucoma.

He himself, besides cataract cases, took patients suffering from various other forms of eye-disease - corneal ulceration, dacryocystitis, iritis, etc.

His/

His results were in contrast to Krämer's. The average Blood Pressure in his controls was 145.2, in his glaucoma cases 162.

Kümmell investigated the diastolic, as well as the systolic pressure, and found that, though here also the glaucoma cases had a higher average than the non-glaucomatous, the difference was not so great as in the systolic pressure.

#### My own Investigations.

My investigations have been made along similar lines to those of the last two observers.

The work was done chiefly in the out-patient department of the University Eye Wards in the Royal Infirmary, Edinburgh. An out-patient department is perhaps not an ideal place in which to take blood pressure measurements, but glaucoma is a comparatively rare disease in Edinburgh - certainly much less common than it is with us in South Arabia - and as by no means every glaucoma case seen in the out-patient department finds its way to the wards, the only way to obtain sufficient cases, in the five months at my disposal, was to study them as they appeared. Cases which were admitted to Hospital were of course studied in the wards also, but in all cases the first examination was made in the out/

out-patient department.

Besides the cases seen at the Infirmary, I had opportunities of examining some cases at two of the Eye Dispensaries in Edinburgh, and finally, through the kindness of their consultants, had opportunities of examining several private patients, either in the consulting-room or in their own homes.

The psυχical factor, of course, is one of the fallacies in blood-pressure measurement, and one which it is almost impossible to avoid, but the conditions in these three sets of patients may be considered from this point of view identical. The atmosphere of the private consulting-room is just as likely to induce tachycardia in the patient, as is the out-patient department of the Hospital or Dispensary! And the advent of a strange doctor with uncanny instruments to a private patient's home is bound to have a similar effect. There are patients, of course, whom nothing upsets, but they may be presumed to be at least as numerous in the series of control cases as in the glaucoma series.

With regard to the control cases, their pressures were taken in the same way as the glaucoma cases in the out-patient department. The patient was/

was placed on a table, and allowed a minute or so to rest after the slight exercise of climbing on to the table. The systolic Blood Pressure was then taken with Hawksley's latest pattern of Martin's modification of the Riva Rocci apparatus.

At first I attempted to take the diastolic pressure also. This I soon gave up, for the following reason. In my apparatus the manometer tube is U-shaped. The result is that every millimetre through which the mercury rises represents a rise of pressure of 2 mm. Hg. The scale is accordingly only half the size of the scale in older patterns of the Riva Rocci, in which the mercury was contained in a straight tube.

On this account the point of maximum oscillation of the mercury, which is usually taken as representing the diastolic pressure, is much more difficult to determine than in the straight tube pattern, and I soon realized that any observations on diastolic pressure I might make in this way would be so uncertain as to be valueless. I am the less concerned at this omission, as Kummell (loc.cit.) has already, using Euret's method of auscultation, studied the diastolic pressure in glaucoma, with negative/



negative results.

As advised by most authorities on Blood Pressure, I took more than one reading of the sphygmomanometer in each patient, and recorded the lowest reading found as the nearest approximation obtainable to the true systolic pressure.

My methods in examining the eye pressure I have already described fully.

The patients in the control series were, of course, not selected in any way.

The following are my lists of glaucoma cases with their blood and eye pressures; and of the control cases with similar data.

Full notes of the glaucoma cases are given in Appendix I.

# EYE AND BLOOD PRESSURES IN GLAUCOMA CASES.

Note:- Eyes on which an operation had been done are enclosed in red brackets:  
Non-glaucomatous eyes in black brackets.

Case No.	Age	Sex	Form of glaucoma.	Eye Pressures. R. L.		Blood Pressure.	Date.	Notes.
I.	80	F.	G. absolute. (Both eyes).	89	104	180	7.2.12	R. acute G. in 1906; L. haemorrhagic; G. in June 1911.
II.	71	M.	Sub-acute G. (Both eyes)	(27-25)	102-96	180	10.2.12	L. quite blind in 1910. R. tre- phined without iridectomy 1910. (Deer.)
III.	71	M.	Simple-chronic G. (Both eyes).	89	(18-16½)	215	10.2.12	R. quite blind in 1910. L. tre- phined without iridectomy Nov. 1910.
IV.	70	F.	Acute G. six months ago. (Both eyes)	(25-21)	(21-21)	210	2.2.12	R. had acute attack Sep. 1911, two days after iridectomy in L. for acute G. & was itself op. on forthwith.
V.	69	F.	Sub-acute G. (Both eyes)	(12-8½)	(2½-2)	220	6.2.12	R. trephined 4.11.10 L. " 5.4.11.
VI.	69	M.	Chronic G. (Right eye)	31-29	(22-18)	130	4.12.11	No operation.
VII.	68	M.	Sub-acute G. (Both eyes)	(48-44 (35-31	82-88 104	200 200	18.11.11 4.1.12	L.E. quite blind P. has been using miotics in both eyes.
VIII.	67	M.	Chronic G. (Both eyes)	(14½-12)	30-23	170	10.2.12	R. trephined with large iridec- tomy 4.8.10. L. blind from G. in 1905. Never op. on.

Case No.	Age	Sex	Form of Glaucoma.	Eye Pressures. R. L.		Blood Pressure.	Date.	Notes.
IX.	65	M.	Simple chronic G. (Both eyes)	68-75 53-51 55	60-56 - (18)	132 106 114	27.1.12 30.1.12 10.2.12	L. trephined on 29.1.12. After pilocarpine bed for a week.
X.	65	M.	Simple chronic G. (L.E.).	- -	36 39 31-28	165 150 152	11.1.12 15.2.12 22.2.12	R. lost in youth.
XI.	65	F.	Sub-acute G. (Both eyes).	43-38 - (14-8)	(25) 27-17 (30-17)	206 194 205	31.10.11 10.11.11 18.12.11	L. trephined on 17.10.11. " " 2.11.11
XII.	64	F.	Sub-acute G. (Both eyes).	31-34	71	125	12.1.12	L. blind for >1 year; R. is under pilocarpine.
XIII.	64	F.	Sub-acute G. (Both eyes).	74	(16-13)	134	22.2.12	R. blind for 18 months. L. blind. 1.8.11.
XIV.	63	M.	Simple chronic G. (R.).	47-45 43-39 25-25 27-30 (18) (13-12) (6-5)	(17) (16-14) (16-12) (19-16) (21) (18-18) (22-19)	112 112 132 126 132 110 122	19.12.11 20.12.11 11.1.12 13.1.12 27.1.12 30.1.12 23.2.12	P. has been using a miotic 11.1.12 b.d. for 7 days. Admit- ted to R.E.I. on this date. R. trephined on 16.1.12 P. has had no drops since operation. (6.2.12)
XV.	62	M.	Sub-acute G. (L.).	(15-14) (14-13) (14-13) (13-10)	30-27 31-27 23-21 (4)	160 124 160 140	13.1.12 17.1.12 6.2.12 22.2.12	P. has been using pilocarpine bd. for 2 weeks. trephined 11.2.12
XVI.								

Case No.	Age	Sex	Form of Glaucoma	Eye Pressures.		Blood Pressure.	Date.	Notes.
				R.	L.			
XVI.	62	F.	Simple Chronic G. (R.) / L.?	54	31-26	178	18.2.12	P. has been using pilocarpine for 2 days.
XVII.	61	M.	Sub-acute G. (R.)	(25-30-26)	(23-19 $\frac{1}{2}$ )	120	8.2.12	R.E. trephined 7.12.10
XVIII.	60	M.	Chronic G. S. (L.)	-	65 (18)	138 144	7.11.11 21.11.11	R. lost in youth. L. trephined 8.11.11
XIX.	60	F.	Acute G. (R)	39-88-82 100	-	165-188 206	17.11.11 21.11.11	L. eye enucleated previously after acute G.
				-	-	144	24.11.11	19.11.11 Posterior sclerotomy
				-	-	136	28.11.11	21.11.11 Eye trephined.
				21	-	160	20. 1.12	
XX.	56	M.	Simple chronic G. (R.) G. absolutum. L.	(39 $\frac{1}{2}$ -35 $\frac{1}{2}$ )	89-77	172	11.1.12	R. Eye iridy. date ? " treph. " ? L. blind for >1 $\frac{1}{2}$ years.
XXI.	56	F.	Simple chronic G. (R.)	40-36 26	-	150 128	25.12.11 1.12.11	L. enucleated for G. 15.8.11
				(5 $\frac{1}{2}$ -5) (13 $\frac{1}{2}$ )	-	120 132	14.12.11 6. 1.12	R. trephined 1.12.11
				(15 $\frac{1}{2}$ -14)	-	118	19. 1.12	
XXII.	55	F.	Sub-acute G. (Both eyes)	(0) (4-2)	(21) (21-18)	200 172	17.11.11 6. 2.12	R. trephined with large iridy in May, L. in June 1911.
XXIII.	54	F.	Simple chronic G. (Both eyes)	39-36 (19 $\frac{1}{2}$ -18)	35 31	132 132	14.12.11 1. 2.12	R. trephined Jan. 6 1912. L.E. under pilocarpine.
XXIV.								



Case No.	Age	Sex	Form of Glaucoma.	Eye Pressures. R. .... L.		Blood Pressure.	Date.	Notes.
XXIV.	53	M.	Prodromal G. (L.)	21-18	23-18	160	11.1.12	P. came to dispensary on 10.1.12 with acute attack in L. Energ. treatment re- sulted in great improvement. (20.12.11)
XXV.	52	M.	Chronic G. S. (R.)	65-51 51-47 39 (11-10) (15 $\frac{1}{2}$ -14 $\frac{1}{2}$ )	(16 $\frac{1}{2}$ -14 $\frac{1}{2}$ ) (13-15) (15 $\frac{1}{2}$ ) (17-14 $\frac{1}{2}$ ) (16 $\frac{1}{2}$ )	122 130 115 118 123	12.12.11 14.12.11 20.12.11 5.1.12 20.1.12	P. has been using 1% piloc. in R.E. since 14.12.11. 22.12.11 R.E. trephined.
XXVI.	51	M.	Subacute G. (Both eyes)	33 $\frac{1}{2}$ -28 $\frac{1}{2}$ (13 $\frac{1}{2}$ )	(17 $\frac{1}{2}$ -8 $\frac{1}{2}$ ) (17)	134 126	11.11.11 24.11.11	L. trephined 30.6.11. R. " 13.11.11
XXVII.	48	M.	Chronic G. end. inac. attack. Chronic G.R.	45-43 36-39	(36-45) (45)	140 136	12.12.11 26.2.12	L. trephined on 1.12.11.
XXVIII.	48	M.	Simple chronic G. (both)	62-53 (30-28) (21)	65-53 51-49 (18-17)	118 122 112	14.11.11 16.12.11 19.1.12	17.11.11 R. trephined. 9.1.12 L. "
XXIX.	46	F.	Acute G.R.	96 70 (27 $\frac{1}{2}$ -26) (30-28)	- - - -	172 140 130 158	16.1.12 18.1.12 1.2.12 23.2.12	L.E. lost from acute G. 18 months ago. P. has been cupped & has had piloc. since 16.1.12. Treph. 19.1.12
XXX.	45	M.	Chronic G.R. Cataract L.	47-45 35 $\frac{1}{2}$ -31 43-39 $\frac{1}{2}$	(18-17) (0) -	138 120 118	19.12.11 16.1.12 17.2.12	29.12. Op. for cat. in L.E. P. has had piloc. bd. for some time. 17.2.12 P. has not used piloc. for 14 days.



Case No.	Age	Sex	Form of Glaucoma.	Eye Pressures.		Blood Pressure.	Date.	Notes.
				R.	L.			
XXXI.	44	F.	Subacute G.L. Chronic G.R.	33-28 33-28 33-30 21-18 $\frac{3}{4}$ 32-22	(70-29) (19 $\frac{1}{2}$ -18) (30-25) (23-22) (32-29)	144 153 150 130 138	27.10.11 17.11.11 25.11.11 14.12.11 4.1.12	The eye treph. on 15.8.11 3.11.11 treph. wound re-opd. Since 25.11.11 P. has had piloc. irid. & nitrits. Piloc. once daily since 14.12
XXXII.	39	M.	Prodromal G.	(13-14 $\frac{1}{2}$ ) (12 $\frac{1}{2}$ )	47 $\frac{1}{2}$ -46 32 $\frac{1}{2}$	136 152	17.1.12 19.1.12	P. has used piloc. for 3 days. P. has not used piloc. since last seen, but has worn his glasses. (19.1.12).

CASES OTHER THAN PRIMARY GLAUCOMA.

No.	Sex	Age	Complaint.	Pressures.			Notes.
				R.F.	L.E.	B.P.	
1	M.	77	Secondary Glaucoma; Myopic Astigmatism.	-	4	180	L.E. Iridectomy 13 years ago.
2	M.	76	Tobacco amblyopia & hypermetropic astigmatism.	17-15½	19-18	246	Urine alb. slight.
3	F.	75	Cataract L.E.	23-19½	30-21	132-182	B.P. increased rapidly from nervousness, but eyes unaltered.
4	F.	73	Sub-hyaloid and other haemorrhages in both eyes.	18-17	18-15½	250	Urine alb. ++.
5	M.	69	"Embolism" of Central Artery.	17-13½	15½-13½	120	The affected eye (L.) has had homatropin & cocaine.
6	F.	66	Cataract.	14-12	18-15½	176	R.E. has had extraction with Iridectomy 4 months ago, L.E. not yet operated on.
7	M.	65	Incipient Cataract; hypermetropia (+1.5).	18-15½	18-15½	163	
8	M.	64	Headaches; slight opacity in media; V. = 6/6.	19½-17	19½-14½	130	
9	F.	63	Early cataract; choroiditis; Myopia (-4D).	18-15½	18-15½	185	
10	M.	62	Cataract, high myopia (>-20D).	9	8½	148	R.E. has been operated on; L.E. not.

No.	Sex	Age	Complaint.	Pressures.			Notes.
				R.E.	L.E.	B.P.	
11	M.	62	Secondary Glaucoma.	27 $\frac{1}{2}$	21	200	30/11/10 L.E. iridectomy; 11/10/11 L.E. trephined.
12	M.	60	"Watery Eyes", Hypermetropia (1D).	14 $\frac{1}{2}$	14 $\frac{1}{2}$	160	
13	M.	60	Cataract.	18	18	202	P. in bed. Urine alb.O.
14	F.	60	Cataract & choroidal change in R.E. L.V. = 6/6.	18	18	210	P. very fat and nervous.
15	F.	60	Cataract.	-	25-17 $\frac{1}{2}$	175	P. in bed.
16	M.	60	Gastric tumour (Medical Patient)	14 $\frac{1}{2}$ -12	14 $\frac{1}{2}$ -12	94	P. in bed.
17	M.	59	Cataract.	12 $\frac{3}{4}$	12 $\frac{3}{4}$	140	
18	F.	58	Detachment of Retina (R.) 2 months ago; Hypermetropia 2D.	12	17-13 $\frac{1}{2}$	208	R.E. under atropine.
19	M.	58	Arterio-sclerosis (medical patient)	17-10	17-10	160	P. in bed
20	M.	58	Cataract; Myopia (-2.5D).	(15 $\frac{1}{4}$ -13 $\frac{1}{2}$ ) (12 $\frac{1}{2}$ )	15 $\frac{1}{4}$ -13 $\frac{1}{2}$ 13 $\frac{1}{2}$	208 142	6/1/12 After 3 days in hospital. N.B. eye pressure taken several minutes after instilling holocaine.
21	F.	57	Cataract (L. R.V. = 6/6	18-16	15 $\frac{1}{2}$ -16	178	

No.	Sex	Age	Complaint.	Pressures.			Notes.
				R.E.	L.E.	B.P.	
22	F.	57	Irido-cyclitis.	18	17	150	Both eyes have been op. on.
23	M.	56	Dislocation of lens.	-	30	170	
24	M.	56	Early cataract.	17	17	148	
25	F.	55	Sub-hyaloid haemorrhage (Albuminuria).	20-15½	17½-13½	235	Ur. alb. +.
26	F.	54	Irido-cyclitis with + tension.	65	-	200	Pressure taken 4 days after operation.
27	M.	54	Cataract.	-	-	138	
28	F.	54	Hypermetropic Astigmatism (P. dropsical).	34-26	34-26	250	Morbus cordis. alb. +.
29	M.	54	Myopic astigmatism; myxodema.	18-17	18-17	120	19/1/12. 27/1/12.
30	M.	53	Optic neuritis; almost central V. only in R.E.	22-14½	19½-16½	145	
31	M.	52	Irido-cyclitis with high tension in R.E.	{ 14½ 12	43-39 18	112 118	
32	M.	51	Injury to R.E., with subse- quent iritis.	30	22	152	
33	F.	50	Headaches; refraction normal.	18-21	23-17	155	R.E. had iridectomy 2 years ago & extraction 9 months ago.
34	F.	50	Cataract.	13½-18	16½-12½	112	

18.

No.	Sex	Age	Complaint.	Pressures.			Notes.
				R.E.	L.E.	B.P.	
35	F.	49	Myopia; disseminated choro- iditis.	14 $\frac{1}{2}$	15 $\frac{1}{2}$	180	
36	M.	48	Iritis & secondary glaucoma in R.E. after perforating injury 11 years ago.	36	19 $\frac{1}{2}$	122	
37	F.	47	Presbyopia.	18	18	144	
38	F.	47	Headaches (Myopia -1.5).	15 $\frac{1}{2}$ -13 $\frac{1}{2}$	15 $\frac{1}{2}$ -13 $\frac{1}{2}$	110	
39	M.	47	Secondary glaucoma.	21	70-62	140	
40	M.	46	Early cataract R.E.	23-19 $\frac{1}{2}$	48	162	R.E. under homatropine.
41	M.	46	Failure of sight (Compensa- tion case!).	15 $\frac{1}{2}$ -13 $\frac{1}{2}$	15 $\frac{1}{2}$ -13 $\frac{1}{2}$	124	
42	M.	46	Headaches (L.E. myopia -2D).	16 $\frac{3}{4}$ -14 $\frac{1}{2}$	16 $\frac{3}{4}$ -14 $\frac{1}{2}$	138	
43	M.	46	Central choroiditis & myopia; R.-4, L.-7.	6 $\frac{1}{2}$ -5 $\frac{3}{4}$	10-7 $\frac{1}{2}$	140	
44	M.	46	Myopia -2D.	14 $\frac{1}{2}$ -13 $\frac{1}{2}$	15 $\frac{1}{2}$ -14	120	
45	M.	45	Myopia (Extreme, over 25D).	15	15	140	
46	F.	42	Headaches.	17	17	142	
47	M.	45	? Stone in kidney (Medical case).	19-12	19-12	-	B.P. not noted.



No.	Sex	Age	Complaint.	Pressures.			Notes.
				R.E.	L.E.	B.P.	
47a.	M.	45	Secondary Glaucoma.	-	19	140	Trephine operation 10 months ago
48	M.	38	Detachment of Retina (R.) Low myopic astigmatism (L.)	39-40	25-16	138	R.E. under cocaine.
49	F.	37	Astigmatism. (Hypermetropic).	21	23	132	P. nervous.
50	M.	36	Injury to L.E.	19½-15	-	132	
51	F.	36	Megrim (Refraction normal).	23-17	25-19	138	
52	M.	35	Detachment of Retina in L.E. High myopia, R. -12, L. -19.	{ 19½-15½ 12	0 2	130 125	5/12/11 6/1/12 After 3 weeks in hosp.
53	M.	34	Secondary Glaucoma in L.E.	15½-13½	70-68	152	
54	M.	32	Tumour of L. orbit. &c. R.V.= 6/6.	{ 9 12-7	-	113- 112-100 -130	15/3/12. 22/2/12. Exercise experiment.
55	F.	31	Transient Scotomata, V.=6/6.	18-15	18-15	152	
56	M.	31	Myopia (High, -15D).	18-13	18-13	134	
57	M.	28	"Weakness" (Medical Patient).	17	17	117	
58	F.	27	Headaches. (Hypermetropic astigmatism, +1D. cyl.)	18	18	128	
59	F.	27	Headaches (Hypermetropic astigmatism. +0.75D).	20	20	124	
60/							

33,

No.	Sex	Age	Complaint.	Pressures.			Notes.
				R.E.	L.E.	B.P.	
60	M.	26	Recovered from Pott's Disease. V. = 6/6.	12-8½	12-8½	122	
61	M.	23	Secondary Glaucoma, high myopia, choroiditis, &c. &c.	25 18-16½	13½ 16½-12¾	142 138	4/1/12 (R.E. has been op. on.) 1/2/12.
62	M.	23	Double Optic Neuritis.	16½-12½	16½-13½	116	
63	F.	22	Retro-bulbar Neuritis (R.).	{ 16¾-14½ 15½-13½ 15½-14½	{ 15½-14½ 13½-14½ 14½-14½	113 112- 100 110) 1320	15/2/12 After exercise.
64	F.	15	Tumour left malar region V. = 6/6.	19½-12	-	118	Under much tonometry.
65	F.	14	Lupus.	-	18-11	114	
66	F.	11	Albuminuric retinitis.	21	21	225.	

In this series of control cases there are included a few cases in which it is noted that the patient was in bed (in the Eye Ward or in a Medical Ward). As rest in bed has often a pronounced effect in lowering the blood pressure, these cases are not strictly comparable with the glaucoma cases examined in the out-patient department.

I have, however, examined many of the glaucoma cases repeatedly after their admission to Hospital. If the results of these examinations are included in arriving at an average Blood Pressure figure for each patient, it would be only fair to include in the control series other patients taken under similar conditions.

In the table which follows I have given in the first column the pressures of glaucoma cases taken in the out-patient department, or under similar psychical circumstances, as already explained; and in the second column my control cases taken in the out-patient department. In the other columns I have included, in arriving at the average blood pressure for each glaucoma case, all the pressure readings taken (before admission and in the wards); and in the control series all cases examined.

To/

To obviate Kummell's objection to data in which the ages of the control cases are not similar to the glaucoma cases, I have arranged all my cases in decades. (No. of cases examined in brackets.)

Age in Decades.	Average Blood Pressure in Glaucoma Cases.		Average Blood Pressure in Control Cases.	
	Out patient readings only.	All readings.	Out patients.	All readings.
80-89	180 (1)	-	No Control cases of this age examined.	
70-79	201.6 (3)	201.6 (3)	215 (2)	198 (4)
60-69	155.8 (15)	155.1 (15)	164 (8)	162.8 (12)
50-59	149 (7)	147.6 (7)	171.8 (10)	163 (13)
40-49	142 (5)	-	138.6 (13)	-
30-39	145 (1)	-	138 (7)	-

The result of these cases is to support Krämer's conclusions rather than Kummell's. In the two age periods in which I had most cases (both glaucoma and controls), viz., 60-69 and 50-59, the pressures in the control cases were higher considerably than those in the glaucoma cases, while in the next most common age period (40-49) the control cases were only slightly below the glaucoma cases in average blood pressure. The figures in the other age periods are too small to draw conclusions from.

In/

In order to compare these results with those of other observers, I have gone through the lists of cases given by Kummell and Kramer, and arranged them also according to age periods. In Kummell's cases I have omitted those which he himself admits might more properly be classed as secondary glaucoma; and also his cases of haemorrhagic glaucoma, as it is so often difficult to tell whether such cases should be classed as primary or secondary.

I have not included Frenkel's cases. A study of his figures, which in his control cases diminish (!) with advancing years, suggests that his blood pressure apparatus (Laulanié's), of which I have no adequate description, is unreliable.

It should be noted that the only two observers who have so far used the modified Riva Rocci, which, as we have seen, is the most reliable form of sphygmomanometer, are Kummell and myself. My results and his are in striking contrast - as, in the three age periods in which the majority of the cases occur, his glaucoma cases have a much higher average blood pressure than the control cases. In the decade 70-79, however, his figures tell in the opposite direction - his glaucoma cases having an average blood pressure lower by 10 mm. than that of his controls.

In/



In this table I have given in my own series only out-patient figures.

COMPARISON OF RESULTS OF THREE OBSERVERS ON  
BLOOD PRESSURES IN GLAUCOMA AND OTHER EYE DISEASES.

Age	Period Average Blood Pressure		Observer	Glaucoma Pressure	Glaucoma Pressure
	Glaucoma	Control Cases		Higher by	Lower by
70-79	115 (3)	103 (23)	Krämer.	7 mm.	
	148 (3)	158.5 (16)	Kümmell.		10.5 mm.
	201.6 (3)	215 (2)	MacRae.		13.4 mm.
60-69	116 (15)	112 (36)	Krämer.	4 mm.	
	163 (3)	150.15 (26)	Kümmell.	17.8 mm.	
	155.3 (15)	164 (8)	MacRae.		8.2 mm.
50-59	119 (15)	110 (18)	Krämer.	9 mm.	
	136 (4)	141.4 (24)	Kümmell.	44.6 mm.	
	149 (7)	171.8 (10)	MacRae.		22.8 mm.
40-49	103 (8)	111 (8)	Krämer.		8 mm.
	160 (6)	133.7 (18)	Kümmell.	26.3 mm.	
	142 (5)	138.6 (13)	MacRae.	3.4 mm.	
	140 6	134 21		6	

(No. of Cases in brackets.)

A study of these figures leads us to the conclusion that the question is not yet settled. In each of the age periods at least one observer finds his control cases with a higher average pressure than/

than his cases of primary glaucoma. Granting that the figures are reliable, these discrepancies can be explained on one of two assumptions.

(1) That there is no tendency to higher Blood Pressure in glaucoma than in other eye patients of the same age; & (2) that the difference in the results of different observers is due to averages being taken from too small a number of cases.

I am aware that my own series is particularly deficient in control cases, But I would submit that the same objection holds for the other observers. To really settle the question absolutely, it would be advisable to have, say, twenty glaucoma cases and a hundred control cases in each decade - the pressures to be taken throughout by the same observer, in identical conditions and with the same instrument. Anything short of this cannot be considered to furnish an adequate basis on which to draw conclusions as to average pressures.

It is useless to take the averages which have been given by physicians, as the normal figures at different ages. For purposes of comparison, the work must all be done by one man.

The work should be also checked by tonometric examination of the eyes in both sets of cases./

cases. The need of this might be exemplified by my own experience. In one of the cases I was examining as a control, the finding of the tonometer was the first indication, confirmed afterwards by testing the field of vision, that the case was one of glaucoma.

A chronic simple glaucoma, without marked excavation of the disc, in which perhaps some refractive error may be found to explain the patient's complaint of poor vision, may very readily be passed over in the hurry of a busy clinique, unless an examination is made with the tonometer.

(2) The other possibility is this:- That there may be a connection between high blood pressure and glaucoma, but that our means of estimating blood pressure are at fault.

It is a curious fact that, while the various observers whose work I have summarized have freely criticized the results of their predecessors, none of them has made any criticism of the form of blood pressure apparatus these predecessors have used. They have in all cases accepted the data given by the instrument in question.

This, as we have seen (in Part II.), is

a/

a serious source of error; and the conclusion we have already come to is that only observations made by the modified Riva Rocci apparatus are of real value.

On the other hand, as we have already seen, there are many authorities who do not consider that even that apparatus really measures blood pressure. Russell's opinion of the Riva Rocci apparatus is, that its readings are the sum of two factors (1) the blood pressure, and (2) the resistance to compression of the artery wall; that we have no means of separating these two factors, and that therefore it is impossible to estimate blood pressure clinically. This is especially the case, of course, in those whose arteries are sclerosed or spastic. Now glaucoma is a disease whose onset is most frequent after the age of 40. By this time changes in the blood-vessels which make them difficult to compress have set in in many people; and therefore, if Russell's contention is right, the attempt to measure blood pressure in glaucoma or in any other disease is foredoomed to failure. Until this question has been settled one way or another by the physicians and physiologists; and, if Russell is right, until the difficulty/

difficulty has been overcome, perhaps by some form of apparatus like the Haemodynamometer of Oliver, which balances instead of obliterating the pulse wave, it does not seem desirable to continue investigations by these methods.

My Experiments in reducing Blood Pressures in Glaucoma.

In order to test the question in another way, I attempted on several occasions in glaucomatous patients and others, to influence the blood pressure by means of one or other vaso-dilator, and to see if any effect was produced upon the eye pressure.

Edwin Matthew (43) has shown that the Nitrites of Sodium and Potassium, in doses of two grains have their maximum effect in 15 minutes; while Liquor Trinitrini in two minim doses acts more quickly, its maximum effect being obtained in five minutes.

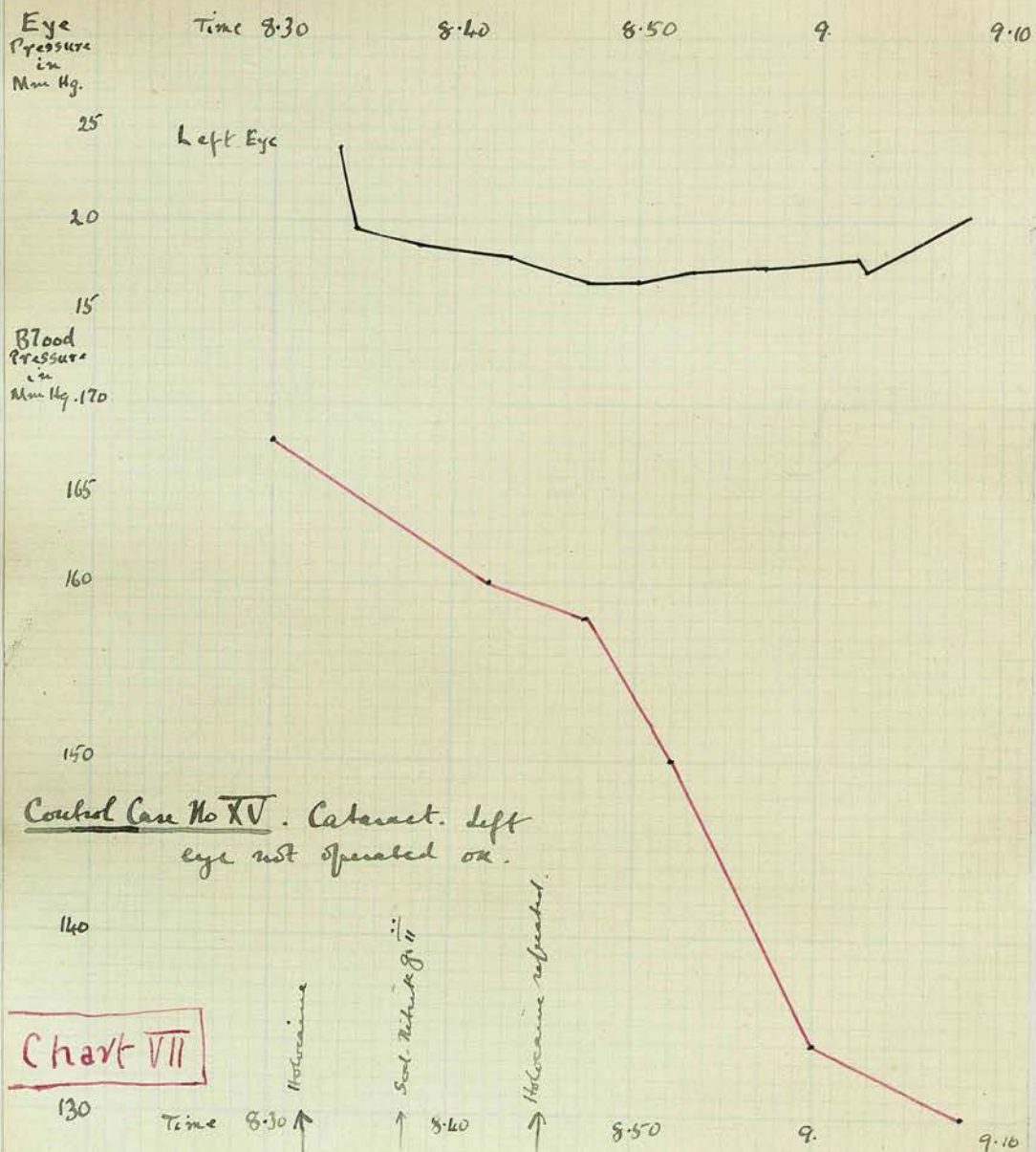
These two drugs were the agents I employed. Blood and eye pressures were first taken; the dose of nitrite was then administered, and the pressures taken at intervals thereafter.

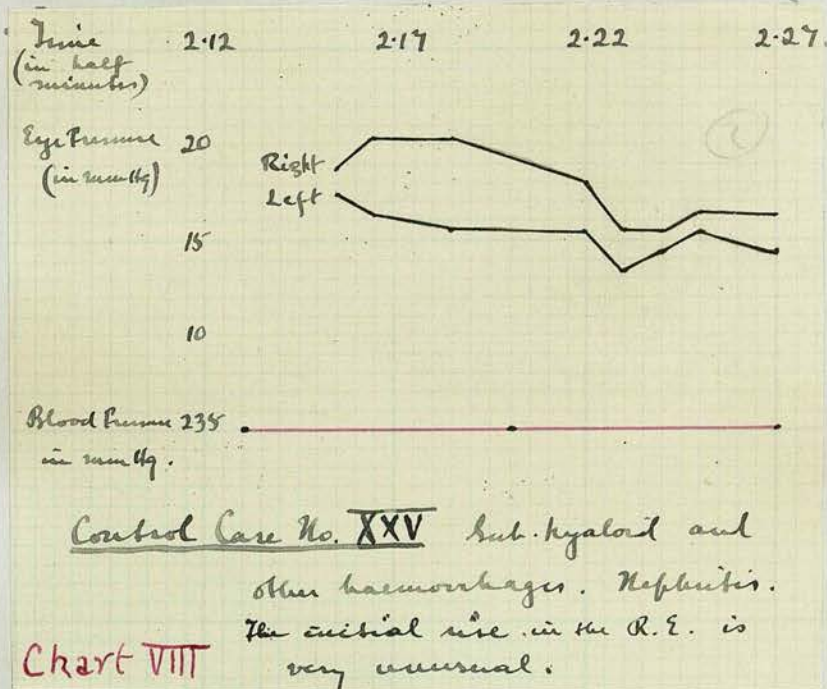
In the control case, No. XV. there was, as my previous experience would lead one to expect, no similarity between the curves. The usual drop in eye/



eye pressure under tonometry was experienced, but nothing to correspond to the drop in the blood pressure caused by the nitrite.

In Control Case No. XXV. no nitrite was administered, and the Blood Pressure remained at the same point throughout, while variations occurred in the eye pressure, as may be seen in the chart.





In the cases of glaucoma in which I tried this experiment, there is little to support the idea that the eye pressure falls with the blood pressure.

In Case XI. (Chart IX.) the tension on 31st October 1911 in the right eye, which had not been operated on, did not show anything to correspond to the drop in the blood pressure.

In/

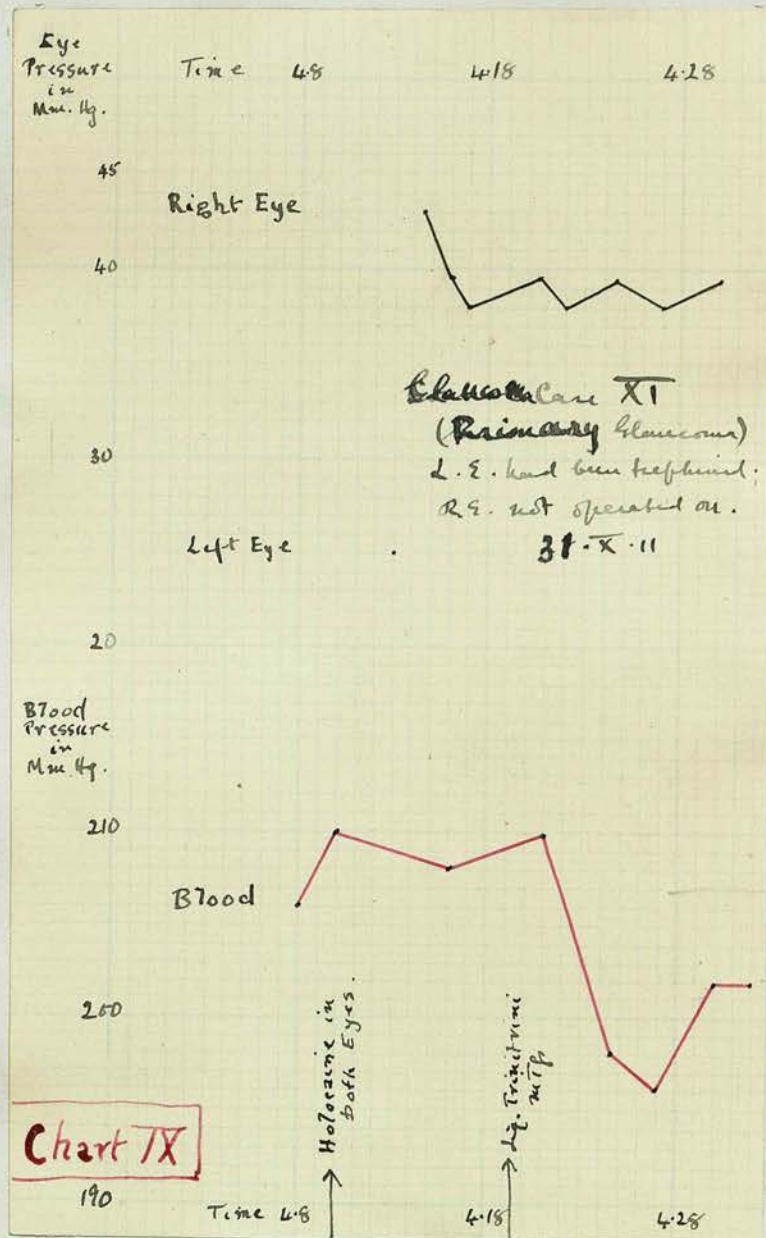


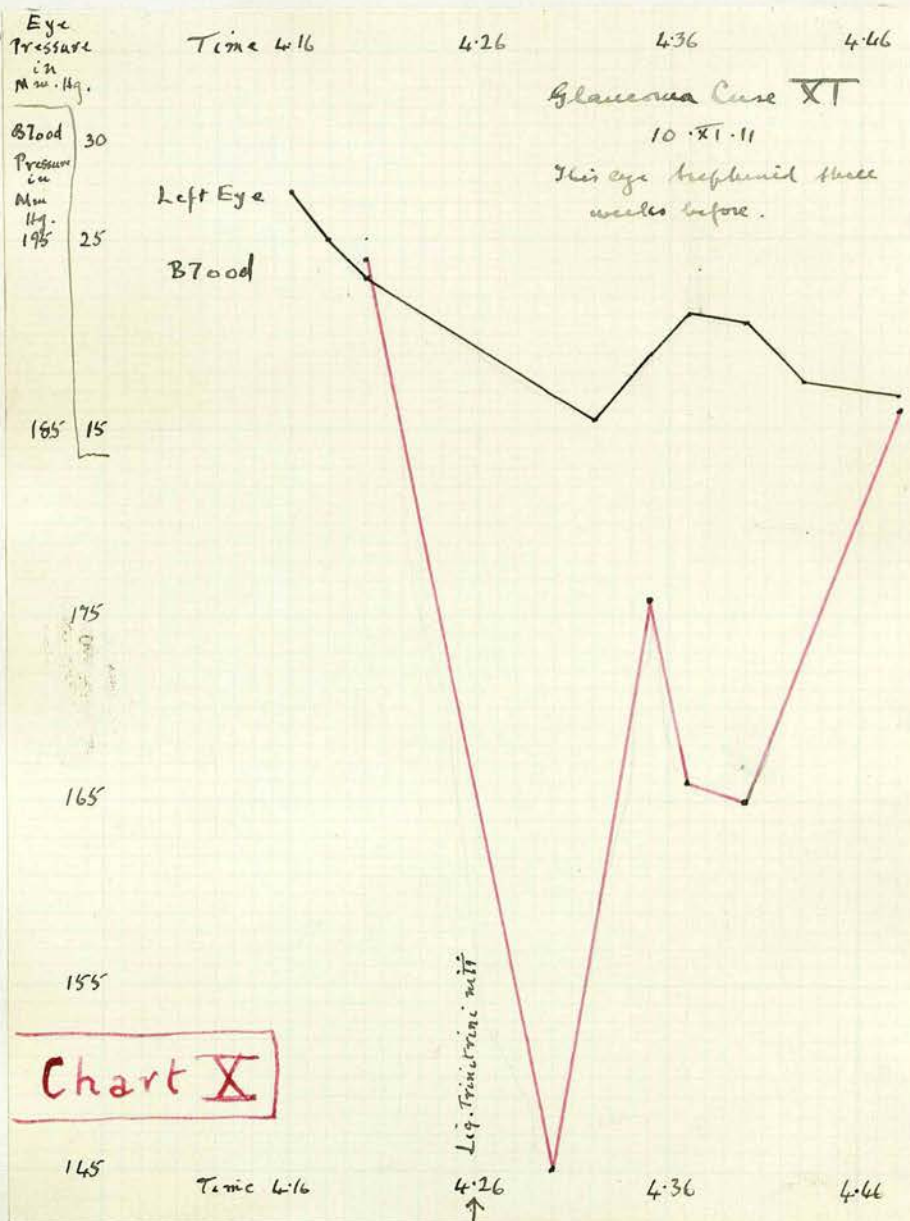
In the same patient on 10th November 1911 (Chart X.), the experiment was repeated with the left eye, which had been trephined three weeks before. There is somewhat greater similarity in the curves in this case, but the objection may be raised that an eye which has been recently trephined is not a suitable eye for an experiment of this kind.

The fact that a filtering cicatrix had been established by the operation is well seen in this chart, and in the left eye of Case XXVI. (Chart XI.). In both the diminution of tension under tonometric examination is abnormally great.

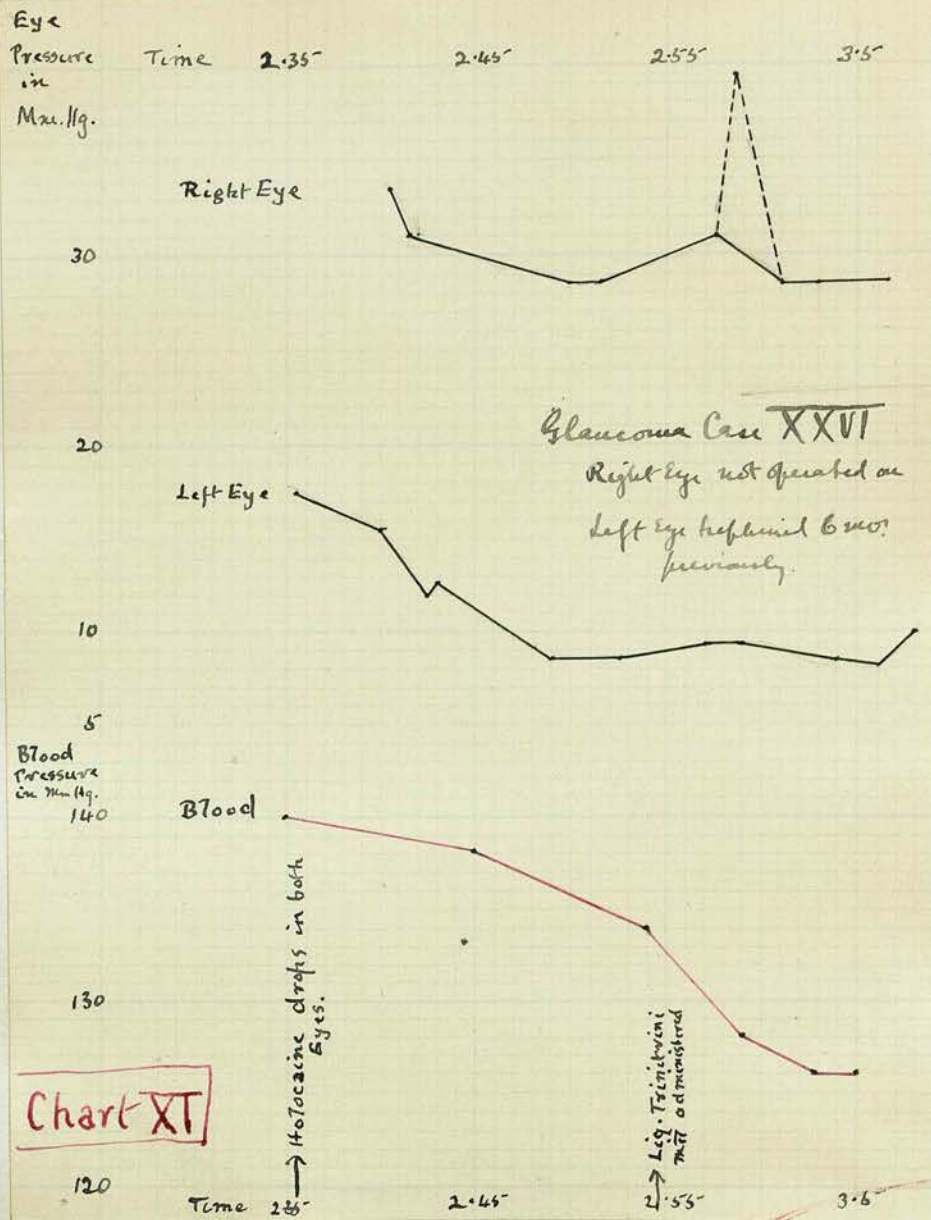
If these charts are compared with charts Nos. I. to VI. (pp. 22/3/4.), of cases in which no vaso-dilator was administered, there is perhaps seen a greater tendency to a continuance of the initial fall in eye pressure in the glaucoma cases after the nitrites had lowered the blood pressure, but it is not sufficiently marked to be of value; and we must conclude that these experiments, while not perhaps disproving any immediate effect on the eye pressure in glaucoma following a diminution/

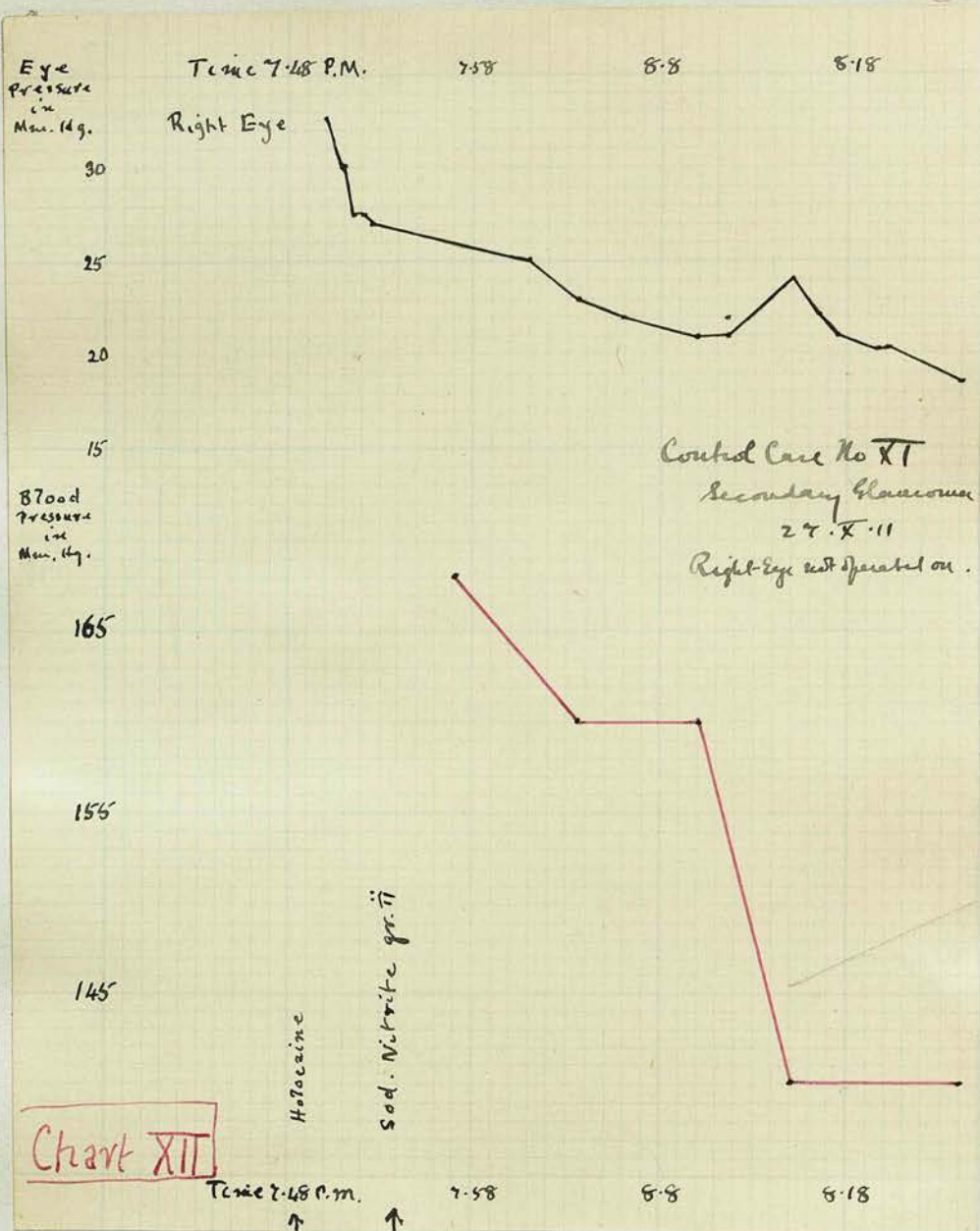
diminution of blood pressure, are certainly not convincingly in favour of such an effect.











To sum up:-

(1) It is certainly the case that high blood pressure may exist without glaucoma.

(2) It is equally certain that glaucoma cases may have remarkably low blood pressures for their age, e.g., cases IX. and XIV.

(3) It is also true that, where the blood pressure is high in glaucoma, its reduction may after a time be followed by a lowering of the eye tension, but this may be because venesection, cathartics, etc., besides acting on the causes of high blood pressure, also act on the causes (whatever they may be) of glaucoma.

(4) Having regard to these facts, and to the results of my own investigations, my conclusion is with Krämer that if Blood Pressure has any influence in glaucoma, it is not one which, so far, has been proved clinically.

Perhaps further improvements in the methods of investigating the blood pressure may bring the needed light.

#### VENOUS PRESSURE IN GLAUCOMA.

Thomson Henderson's recent work (44) on Glaucoma, in which he contends that the intra-ocular pressure is the same as the venous pressure, and rises/



rises and falls with it, suggested the advisability of testing venous blood pressure in my cases. There are two methods of doing so described by Oliver (45) in his book. One is, to use a finger-cuff ( in combination with the Riva Rocci apparatus) to obliterate a prominent vein on the hand or forearm. The vein must be without branches, and must have a competent valve. The cuff is applied at the distal extremity of the vein, and is blown up to a pressure of 40 mm. Hg. The finger is then run along the vein, to drive the blood in it past the next valve. The pressure in the cuff is then gradually lowered, until the vein suddenly fills from below, and this point is taken as the venous pressure.

I have tried this method, but without much success. It is only in a few cases that a suitably placed vein is found, sufficiently full to make observations easy, and with a competent valve. In some cases, even when the valve seems competent, the vein gradually fills, before the pressure in the cuff has been reduced - possibly through small tributaries from the deeper veins.

Oliver's other method is to lift the patient's arm, until the veins on the back of the hand/

hand suddenly collapse. The distance in inches at which the hand then is above the apex of the heart is noted. This figure multiplied by two gives the venous pressure in mm. Hg.

One difficulty in using this method is, to get the patient to leave his hand flaccid - an impossible feat for many patients. Muscular contraction drives the blood from the deeper to the superficial veins, and gives a false result.

Both methods depend on there being prominent veins on the hand and forearm. Their pressure depends to a large extent on whether the patient is warm or not; and during the winter, in the climate of Edinburgh, I found it surprisingly difficult to get suitable veins.

In the few cases where I was able to get a reasonable approximation to the venous pressure, by one or other method, I did not find it increased.

In this connection, an observation of Maynard's (46) is interesting. He saw, during an outbreak of epidemic dropsy in Calcutta, a considerable number of cases with high intra-ocular tension. The blood pressure, when tested, was found to be low, but, presumably from the nature of the disease, the venous/



venous pressure was high.

These facts recall the case of anasarca, to which I have referred (Control Case No. XXVIII.), in which I found the eye pressure above normal.

It would be worth while examining the eye pressures in cases of anasarca in the medical wards, to see if there is any tendency in them to high intra-ocular pressure, or whether in my case the high eye pressure was merely a coincidence. I regret that I have not had time to do this myself.

I have much pleasure in acknowledging my indebtedness to Dr. Mackay, from whose clinique and wards the great majority of my cases were taken, and who very kindly placed his excellent library of ophthalmic literature at my disposal; to Drs. Paterson and Traquair, who also helped me by allowing me to examine patients under their care; and to Dr. Gibson, who advised my choice of a blood pressure apparatus, helped me in getting at the literature of that subject, and gave me free access to his wards in the Infirmary.

SUMMARY/

SUMMARY OF CONCLUSIONS.  

---

1. In 48 normal eyes I did not find that the tension increased with increasing years.
2. Several points are given in connection with the use of the tonometer which do not lend themselves to summarization.
3. I have proved that the pulsations of the tonometer lever are due to the patient's pulse, not to that of the observer.
4. In normal eyes there is a tendency to a steady diminution of tension under repeated examination with the tonometer. Charts illustrating this are given.
5. In glaucoma the tension in similar circumstances sometimes rises.
6. My experience coincides with that of Schiötz, viz., that no normal eye has a tension above 25 mm. Hg.
7. I do not agree with him that no normal eye has  
a/

a pressure below 15.5 mm. Hg. Two patients with perfectly normal eyes had pressures of 12; one of these on another occasion had a pressure of 9 mm. Hg.

8. The tonometer is of great value (a) in diagnosis; (b) in watching the result of treatment; (c) in deciding whether to operate or not; (d) in watching the effect of operations.
9. After operation for glaucoma, extreme and long-continued hypotony is possible with no apparent ill effects.
10. The tonometer is a delicate instrument, and records small variations of tension, especially in the lower grades.
11. Of Blood Pressure instruments, the modified Riva Rocci is the best.
12. But many authorities consider that the condition of the vessel wall greatly affects its readings, and that so far there is no clinical method of actually determining the Blood Pressure.
13. The Blood Pressure is a factor in maintaining Intra-ocular/

Intra-ocular Pressure, but not the sole factor.

14. In three young patients I found that exercise sufficient to raise the Blood Pressure 20, 30, or more mm. did not affect the Eye Pressure.
15. In some of my control cases a rise of Blood Pressure occurred during examination, but no rise of Eye Pressure.
16. In some control cases who were examined twice, there was a considerable change in the Blood Pressure reading on the second occasion. In some of these there was a corresponding change in the Eye Tension; in others there was not.
17. In 51 control cases arranged according to the height of their Blood Pressure, the average Eye Pressure does not correspond.

My conclusion from the data (13-17) is that in normal eyes the condition of the Blood Pressure does not influence the height of the Intra-ocular Pressure.

18. In Glaucoma. A lowering of Blood Pressure, e.g., by venesection, has often been followed by a lowering of Eye Pressure.
19. Many observers have found a higher Blood Pressure in glaucoma than in other patients, but the results of some are valueless because of the apparatus they used.
20. My results in 31 glaucoma cases and in 56 control cases of similar age periods are given, and show a lower level of Blood Pressure at the ages at which glaucoma is most frequent in the glaucoma cases than in the controls.
21. These figures are compared with those of 2 recent German observers. The conclusion is that this point is not yet settled. The discrepancies between different observers may be due to (1) too few cases being examined; (2) the belief held by many being a true one, that Riva Rocci readings are so dependent on the vessel wall as to be valueless as indications of Blood Pressure.
22. My experiments in reducing Blood Pressure with nitrites/



nitrites are inconclusive with regard to the result on the Eye Tension.

23 & my conclusion is that, if high Blood Pressure has an aetiological connection with glaucoma, it is not one that has yet been proved clinically.

24. The question of the venous pressure in glaucoma is touched on finally.

---

A P P E N D I C E S.

---

CASES OF PRIMARY GLAUCOMA EXAMINED.

Case 1 Mrs. McA. aet. 80.

Disease: Absolute Glaucoma, both eyes.

7/2/12. History: About 7 years ago R.E. had attacks of dulness of vision. A year later P. had acute attack and lost her sight in a fortnight, being treated with atropine in both eyes! L.E. began to get blind 2½ years ago. April 1910 she consulted Dr. Paterson, who did not recommend operation. Her field was fairly good. P. was able to read with glasses. In June 1911 P. had a haemorrhage in L.E. during the night and lost her sight. A few days later she had an attack of acute Glaucoma in that eye.

Present condition of Eyes: R.E. No pupillary aperture visible: cornea steamy. L. pupil moderately dilated: does not react.

R.V. = 0, L.V. = 0.

Pressures: R.E. 89

(2 p. m.) L.E. 104

B.P. 180 (Arteries thick & tortuous.

P. has been in bed since last night.)

Case 2 T.S. aet. 71. Gardener.

Disease: Sub-acute Glaucoma, both eyes.

History: P. was admitted to R.I.E. on 19/12/10 with the following history:— L.E. has been failing for 18 months and is now quite blind. R.E. began to fail 6 months ago, with attacks of headache. Twelve months ago he was seen by a doctor in Carlisle and was ordered drops. At that time he was able to find his own way. Urine: no albumen. L.V. = P.L. (?). R.V. = H.M. at 2 metres. R. pupil is contracted under pilocarpine. Media clear: ant. ch. shallow: field much diminished, especially on nasal side: T.+2. L. pupil contracted and immobile: ant. ch. shallow. B.P. 178. R.E. was trephined by Dr. Mackay on 21st Dec. 1910. No iridectomy was done.

10/2/12. P. came to R.I.E. to-day to show himself.

He thinks sight much the same as at the time of operation, perhaps slightly diminished. P. has sometimes a little pain in the eyes, especially the L.E.

Condition of Eyes: L. pupil contracted and immobile; ant.ch.shallow; cornea steamy; disc not seen.

R. pupil contracts slightly rhythmically, but not to light; disc markedly cupped and atrophic; veins not dilated. R.V. = H.M. at 8 metres. Field much contracted on nasal, but fairly good on temporal, side.

Pressures R.E. 27-25

(1 p.m.) L.E. 102-96

B.P. 180 (P. slightly nervous:  
arteries thickened.)

Case 3 R.B. aet. 71. Shoemaker.

Disease: Simple chronic Glaucoma, both eyes.

History: P. came to R.I.E. on 5th Nov. 1910 with the following history:- Twelve months ago he noticed haloes at night. Since then his R.E. has gradually failed. He has never any pain in the eyes but sometimes a feeling of heaviness.

R. pupil dilated and immobile; media clear; disc cupped; vessels tortuous; T. +2. R.V. = 0.

L. pupil contracted and a little sluggish; media clear;

T. slightly+. L.V. with +2.25 D. sph. = 6/9, B.P. 182.

On 10th Nov. 1910 the L.E. was trephined by Dr. Mackay without iridectomy. P. left Hospital on 2nd Dec. 1910.

On Dec. 24th at O.P.D., B.P. 215: L.V. with 2.25 D. sph. = 6/9.  
10/2/12.

Condition of Eyes:-

R. pupil dilated and immobile: some peripheral opacities in lens: very marked cupping: V. = 0.

L. pupil contracted, reacts to light. There are some spots of iris pigment on the front of the lens: fundus not visible. V. with +2.5 D. sph. = 6/9.

Pressures: R.E. 89

(1.30 p.m.) L.E. 18-16½

B.P. 215 (Artery wall thickened).

Robert Bowie

10.11.12

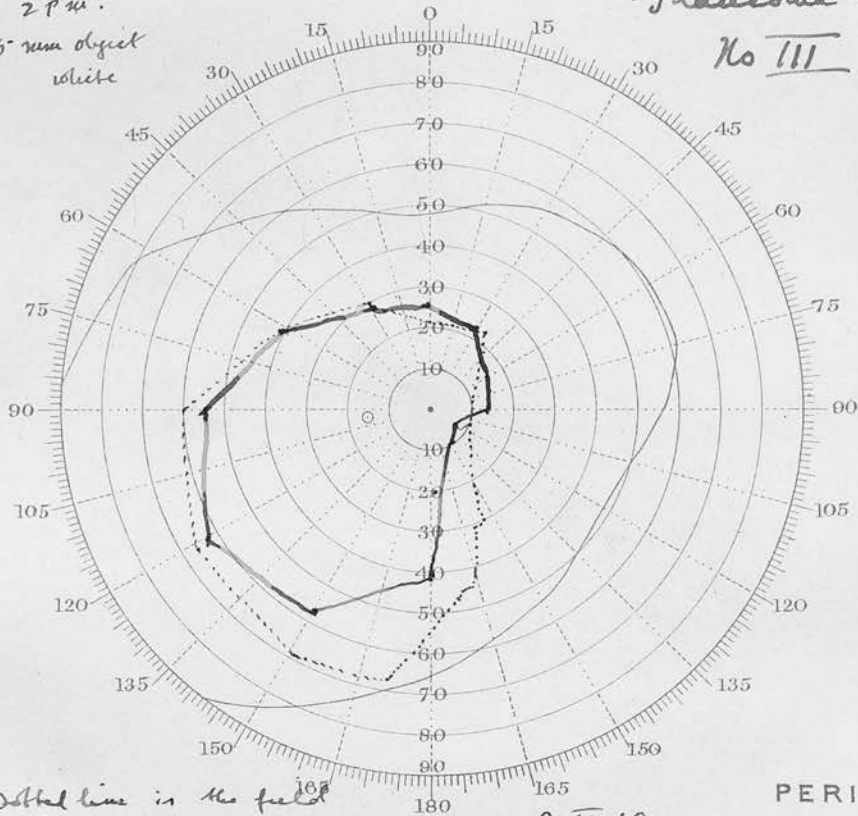
2 PM.

5 mm object  
white

"Centre each chart with 'pointer' at Zero before

LEFT.

Glaucoma Case

No III

Dotted line is the field  
with 5 mm. white object recorded on 9.21.10

The eccentric continuous red line indicates the average normal field.  
Designed for use with Prof. McHardy's Registering Perimeter.



Case4 Miss G. aet. 70.

Disease: Acute Glaucoma (six months ago) in both eyes.

2/2/12. History: Had excellent vision till July '11, when L.E. got hazy and very painful at nights, but only then. These attacks sometimes absent for a week at a time.

About Aug. 23rd had an attack, but she was treated by her doctor, who did not recognise the disease. P. whose sister (Case1) had lost her sight from Glaucoma, eventually insisted on seeing Dr. Paterson and was admitted to R.I.E. When admitted P. saw haloes with R.E. also. Iridectomy was performed by Dr. Paterson on Friday the 8th Aug. '11. On the Sunday night the R.E. which had never been painful previously, had an acute attack. As it was uninfluenced by miotics Dr. Paterson performed iridectomy on Tuesday 12/11/11.

Present condition of Eyes: - Coloboma upwards in both.

R.E. P. is able to read with glasses (+3).

L.V. = C.F. at one foot. Field very constricted.

Pressures: R. 25-21 P. is still using weak eserine(.25%) once daily in both eyes.

B.P. 210, but P. is nervous. There is slight oedema of the eye-lids; artery wall thick and tortuous.

Case 5 Mrs McN. aet. 69.

Disease: Sub-acute Glaucoma.

History: Ten years ago consulted Dr. Sym about her eyes, and was given drops.

Mar. 23, 1910 came to R.I.E. with an acute attack in L.E.

V. = 6/60: under leeching and miotics on Mar. 25th V. = 6/9; - attack subsided.

It was noticed that her B.P. was generally high and she

was given iodide and nitrite.

On Oct. 29th, 1910 P. was admitted to R.I.E.

L.V. with +3.5 D. sph. = 6/6. R-V- With +2.5 D. sph. = 6/18. and on Nov. 4th the R.E. was trephined by Dr. Mackay.

Dec. 13th, 1910 L.V. with +3.5 D. sph. = 6/6. R. with +2 D. sph. = 6/18.

Apr. 5/1911 L.E. trephined by Dr. Mackay: ant. ch. was long in re-forming and P. complained of irritability in the eye.

L.V. 6/12-, unimproved by glasses.

B.P. 190. urine normal.

6/2/12.

Condition of Eyes: R.V. with +2.5 D. sph. = 6/24-.

L.V. with +2.5 D. sph. = 6/36.

Both fields much diminished above and slightly on nasal side.

Pressures: R.E. 12-8½

(1.30 p.m.) L.E. 2½-2

B.P. 220.

Case 6 Mr. F. aet. 69. Retired Anglo-Indian Civilian.

Disease: Chronic Glaucoma (R.)

History: (Kindly supplied by Dr. Mackay from his private notes):— P. had iritis at age of 21 in R-E. Vision never good since, has been worse of late, and lately some blurring of vision in the L.E.

4/12/11.

Condition of Eyes:— Signs of old iritis in both eyes (posterior synechiae superiorly). Pupils react to light; ant. ch. shallow in R.E. and R. field of vision is contracted; there is distinct cupping of R. disc. In L.E. ant. ch. slightly shallow; field good, disc not cupped.

R.V. with -1.25 D. sph. +3.5 D. cyl 180° = 6/24

with addition for presbyopia = J4

L.V. with 0.65 D. sph. +3.5 D. cyl. 180° = 6/6-.

with addition for presbyopia = J1.

Pressures R.E. 31-29

(11 a.m.) L.E. 22-18

B-P. 130

Venous P. about 11 mm.Hg.

(Dr. Mackay does not consider this a case of secondary Glaucoma, as there are only slight changes visible in the eye, referable to the iritis of 48 years ago.)

Case 7 J.G. aet. 68, Coachman.

Disease: - Sub-acute Glaucoma

18/11/11.

History: Three years ago first noticed his sight getting dim, was able to read till 18 months ago, and able to drive until 16 months ago. He used to prefer a dull day for driving. After a bright day had a feeling as of sand in the eye, - never much pain.

Condition of Eyes: - R. pupil reacts to light, is moderately dilated; ant.ch. shallow.

L. pupil does not react, pupil is dilated irregularly but not very widely; old synechiae (posterior) present; ant.ch. shallow. Eye is slightly congested. R.V.=C.F. at 4 feet: L.V.= 0.

Pressures: R.E. 48-44

(1 p.m.) L.E. 82-88

B.P. 200

Urine ac., sp.gr. 1022, albumen 0.

4/1/12. P. had an acute attack in L.E. a few days ago. The pain has been relieved by leeching. The cornea is steamy, pupil oval and fixed and eye congested.

Pressures: R.E. 35-31 (P. has been using mi-  
(1.30 p.m) L.E. 104 otics.)

B.P. 200

Case 8 P.S. aet. 67. Millworker.

Disease: - Chronic Glaucoma.

History: - P. came to R.I.E. on Aug. 3rd, 1910 with the following history: - He has worn glasses for work for about 8

commencing to use the Automatic Registration."

*Glaucoma Case*

No VIII

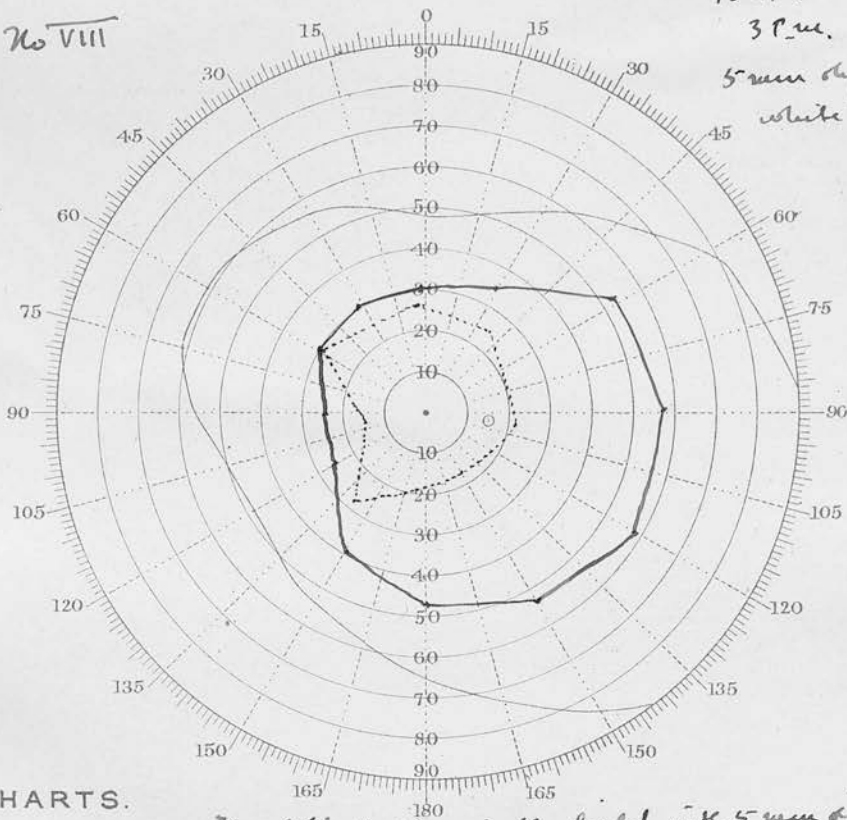
RIGHT.

P. S. Smith

10.11.12

3 P.M.

5 mm object  
white.



R CHARTS.

The dotted line is the field with 5 mm object  
of Indirect Vision, the small red circle the position of the blind spot.  
recorded on Aug. 5<sup>th</sup> 12:10

Published by Mess<sup>rs</sup> Curry & Paxton, 195, G<sup>th</sup> Portland St., London, W.



years; 7 years ago L.E. began to fail; 5 years ago he saw Dr Berry, who said L.E. was blind and advised operation for R.E. He has used drops in R.E. for 2 years. As sight is gradually going, has come to R.I.E.

Condition of Eyes on 3/8/10:- R.V. = C.F. at  $5\frac{1}{2}$  metres :

L.V. = 0.

R. pupil is contracted (miotic), responds slightly to light T. +.

L. pupil moderately dilated; reacts to light; T. +2,  
B.P. 195.

On Aug. 4th R.E. was trephined by Dr Mackay with a large iridectomy; Aug. 14th R.V. = 5/36 with +3 D.sph. = 6/9-. Field much contracted. (See Chart.)

P. was discharged on Aug. 15th to use pilocarpine b.d.

On Sep. 24th R.V. with +3.5 D.sph. = 6/9-.

Dec. R.V. with +3.5 D.sph. = 6/12.

10/2/12.

P. came up to show himself at R.I.E. He thinks his vision is nothing worse since the operation.

Condition of Eyes:-

L.E. pupil contracted; no direct, but consensual reflex to light; ant. ch. shallow; very marked cupping and dilated veins; V. = 0.

R.E. large coloboma from iridectomy. Iris reacts to light; cupping of disc; veins not so dilated as in the L.E.

R.V. with +3.5 D.sph. = 6/12. Field (See Chart)

Pressures: R.E. 14 $\frac{1}{2}$ -12

(2 p.m.) L.E. 30-23

B.P. 170

Case 9 J. McL. aet. 65, House-carpenter.

Disease:- Chronic Glaucoma.

27/1/12.

History: P. did not know there was anything wrong with eyes till, three years ago, he noticed his sight was failing. Since 13 months ago he has not been able to read. He has noticed haloes for 2 years, but



does not know in which eye. L.E. has been useless for more than 2 years.

Condition of Eyes:-Both pupils moderately dilated; R. does not react; L. reacts very slightly and sluggishly to light.

R.V. = P.L.(?) sometimes sees a light but projection almost nil. L.V. = H.M. at 1 metre.

Pressures:- R.E. 68-75

(1.30 p.m.) L.E. 60-56

B-P. 132

Subsequent history:-P. was admitted to R.I.E. on 27/1/12; kept in bed, treated by purgatives &c. and the left temple leached.

28/1/12 L.E. trephined by Dr. Mackay.

30/1/12, (2.30 p.m.) L-E. 53½-51.

B.P. 106.

10/2/12, (6.30 p.m.) R.E. 55.

L.E. 18.

B.P. 114.

Case 10 J.T. aet. 55, Railway Carpenter.

Disease: Chronic Glaucoma.

11/1/12.

History: R.E. blind from an accident 45 years ago. P. began to lose peripheral sight in left eye three years ago, the first thing he noticed being that he could see the lower windows of a house but not the upper. He has never had any pain in the eye, nor has he noticed haloes.

Condition of Eyes:-Pupil moderately dilated; does not react to light; ant.ch. shallow; media clear; disc markedly cupped and atrophic. L.V. = 6/9-. Extreme contraction of field in all directions.(See Chart.)

Pressures: L.E. 36

(2 p.m.) B.P. 165(P. very restless and nervous.)

*Glaucoma Case*

*No X*

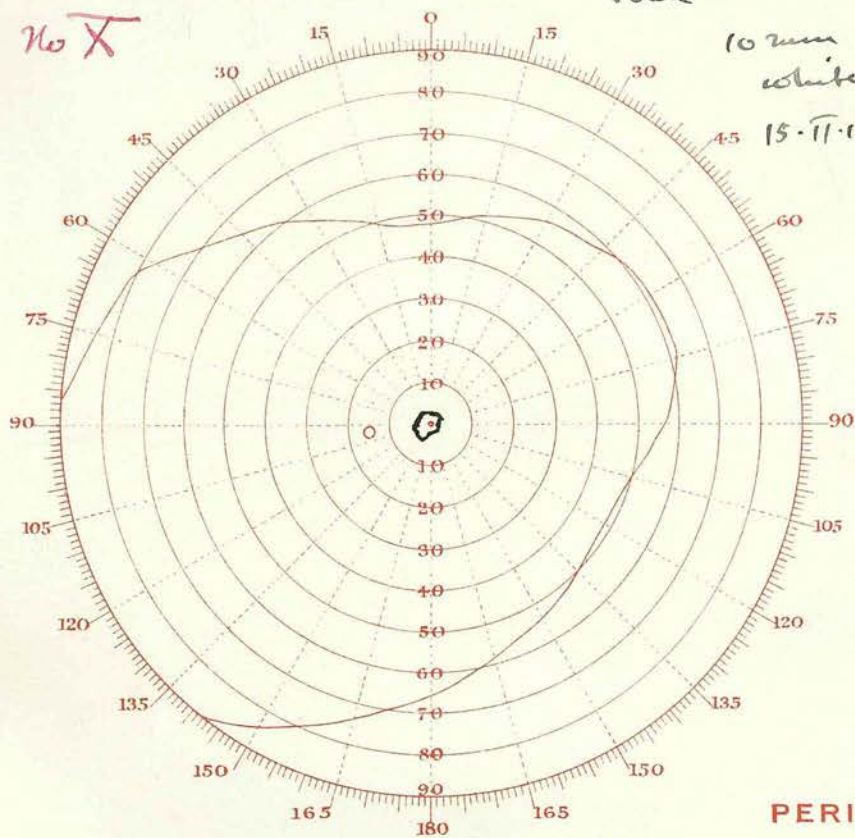
"Centre each chart with "pointer" at Zero before

LEFT.

*John Toddler*

*10 mm  
white*

*15.11.12*



*The eccentric continuous red line indicates the average normal Field*

Subsequent history: P. was given pilocarpine to use but found it irritated his eye and he gave it up after a few days. He returned to O.P.D. on 15/2/12.

L.V. = 6/12, not improved by any glass.

Pressures: L.E. 39½

(2p.m.) B.P. 150

22/2/12 P. has used eserine ½% b.d. since 15/2/12.

Pressures: L.E. 31-28.

(1.15p.m.) B.P. 152.

Case 11 Mrs. D. aet. 65, House-wife.

Disease: Sub-acute Glaucoma.

31/10/11.

History: Five or six years ago P. noticed haloes with L.E. and failing vision. Two and a half years ago she was told by a doctor she had cataract. At that time she had still fair vision. This gradually got worse, but P. was not aware that the sight in L.E. was entirely lost until she came to Cambridge St. Dispensary on 14/10/11. Her left eye was painful and it was trephined by Dr Paterson to relieve the pain, on 17/10/11. She has never had much pain in R.E.

Condition of Eyes:—R. pupil semi-dilated; reacts sluggishly to light; ant.ch. shallow; disc cupped.

R.V. =

L.E. recent coloboma from iridectomy at the trephine operation; disc cupped L.V. = 0.

Pressures: R.E. 43-38.

(4p.m.) L.E. 25 (only one reading taken because of recent operation).

B.P. 203 (artery wall thickened and tortuous; no patches of atheroma.)

Subsequent history: R.E. trephined by Dr Paterson on 2/11/11.

10/11/11.

Pressures: L.E. 27½-17.

(4p.m.) B.P. 194.

18/12/11.

P. came to Dispensary to report

Pressures: R.E. 14½-8½

(4p.m.) L.E. 30-17

B.P. 205

Venous pressure impossible to take as P. is unable to relax her arm muscles.

Case 12 J.C. aet. 64.

Disease: Sub-acute Glaucoma (both eyes.)

12/1/12.

History:-L.E. has been gradually getting blind for 16 years. Absolutely blind now for a year. Has noticed diminution of sight in R.E. for over a year. Has occasional attacks of pain, which is worse at night.Condition of Eyes:-R. pupil reacts sluggishly to light; contracted by pilocarpine; disc cupped; R.V. = 6/12. Field very contracted.

L.E. Glaucoma absolutum; cornea steamy; V.= 0.

Pressures:R.E. 31,30,33,34 (P. is using pilocarpine.)  
(4p.m.)

L. E. 71

B.P. R. 125, L. 133 (p. is phthisical, R. side most affected.)

Case 13 Mrs H. aet. 64.

Disease: Sub-acute Glaucoma.History: P. came to R.I.E. 10/5/10 with the following history:-Illness began with an attack of pain in the L.E. in Sept. '09. This subsided under treatment. Soon after she noticed sight in the R.E. diminishing and she was treated as an O.P. in Glasgow with eserine drops till April 1910, the sight gradually failing, till now there is barely P.L. Six weeks ago L.E. again got sore and was treated also with eserine.



There was dacryocystitis in this eye which was treated. The R. pupil was slightly dilated and immobile; cornea steamy; T. + ; V. = 0; L. pupil small, almost immobile. Urine alb. 0; sp. gr 1023.

On July 1st 1910 Dr Paterson performed iridectomy in L.E.

On July 2 R-V. = 0. L.V. 6/18 with +1.25 cyl. 180° = 6/18

On Dec. 20, '10 L.V. with -0.5 D. sph. +1.25 cyl 180° = 6/9-.

22/2/12 P. came to R.L.E. to report. She sometimes has headaches, chiefly on left side. No pain now in R.E.; no haloes seen with L.E. She thinks sight is dimmer than it used to be. She is still using pilocarpine (1%) once daily.

Condition of Eyes:- R. pupil since dilated, irregular, immobile; cornea steamy; ant. ch. very shallow; lens opaque. R.V. = 0;

L. coloboma from iridectomy, disc atrophic and cupped.

Pressures: R.E. 74

(1p.m.) L.E. 16½-13½

B.P. 134

L.V. with -0.5 D. sph. +1.25 cyl.  
180° = 6/6-.

Case 14 J.H. aet. 63. Norwegian Sailor.

Disease: Simple chronic Glaucoma.

History: 19/12/11. Six months ago noticed accidentally that the the R.E. was rather blind; he has had no pain in it, nor has he seen haloes.

Condition of Eyes:- Ant. chambers not shallow; both pupils react to light (direct and consensual reflex); cornea clear.

R.V. with +2

L.V. 6/24 with +1.5 D. sph. = 6/6.

Pressures: R.E. 47-45

(2p.m.) L. E. 17

B.P. 112. Urine normal.

Note very low pressure in a man of his age and



occupation.

Venous pressure impossible to estimate. as no  
veins stand out on hands.

Subsequent history:-

20/12/11. Pressures: R.E. 43-39½.  
(12 noon) L.E. 16-14½.  
B.P. 112.

11/1/12. P. has been using a miotic in L.E.b.d. for  
over a week.

Pressures: R.E. 25(4 measures identical-  
(1p.m.) last after 5 minutes interval.  
L.E. 16½-12.  
B.P. 132.

Admitted to R.I.E. to-day  
13/1/12. P. complained of some pain for an hour  
or so this morning after his drop of pilocarpine;  
He has noticed this once before.

Pressures: R.E. 27½, 28, 30  
(3p.m.) L.E. 19½-18½  
B.P. 126.

16/1/12 R.E. trephined by Dr MacKay.

27/1/12 P. has been out of bed for 4 days- last  
two days all day

Pressures:- R.E. 18 (no drops in eye  
(3.45 p.m.) since operation)  
L.E. 21  
B.P. 132.

30/1/12.

Pressures:- R.E. 16½-12½  
(3p.m.) L.E. 18-12½  
B.P. 110

23/2/12. P. returned from Convalescent Home to  
show himself at R.I.E.

Pressures: R.E. 3½-5½  
(3p.m.) L.E. 21-19½  
B.P. 122

Case 15

G. J. aet. 32. Rope-spinner.

Disease: Sub-acute Glaucoma. (L.E.)

13/1/12.

History:— R.E. has had poor vision as long as he remembers. L.E. seen by Argyll Robertson some years ago because of headaches and redness of eyes.

Condition of Eyes: R.V. = C.F. at 2 feet.

L.V. with +1 D. sph. +0.25 D. 18<sup>3</sup>/<sub>8</sub>

There is scarring of cornea in R.E. Iris reacts well in both eyes to direct and consensual test.

R.E. large sclerotic patch continuous with disc, most marked on temporal side, with some patches of pigment. There are also patches of choroiditis in periphery. Disc not cupped.

L.E. lunule of pigment above the disc. L. disc distinctly cupped.

Pressures:— R.E. 15½-14½

(2.30p.m.) L.E. 30-27½

B.P. 160

17/1/12.

Pressures:— R.E. 14½-13

(11 a.m.) L.E. 31-27½

B.P. 124

Note these pressures were taken after taking P.'s fields (Q.V.)

6/2/12.

Pressures:— R.E. 14½-13½

(2.30p.m.) L.E. 23-21

B.P. 160

P. has been using pilocarpine b.d. for 2 weeks.

11/2/12. L.E. trephined by Dr Mackay.

22/2/12.

Pressures:— R.E. 12-10

(2.30p.m.) L.E. 4

B.P. 140

Case16 Mrs. W. aet 62.

Disease: Chronic Simple Glaucoma

18/12/11.

History: - R.E. has been losing the sight for some time, but has got rapidly worse during the last month.

Condition of the Eyes: - Pupils react; ant. chambers are of normal depth; media clear in both eyes.

R.E.: Field very diminished, V. = C.F. only with difficulty at  $\frac{1}{2}$  metre eccentrically. Small eccentric field to outside. Disc markedly cupped and atrophic.

L.E.: V. with -1.5 D. cyl.  $75^{\circ}$  = 6/9+. Field normal (Notes of V., fields, &c. kindly furnished by Dr. Paterson.)

Pressures: R.E. 54.

(4p.m) L.E. 31, 30, 26 (P. using pilocarpine for two days).

B.P. 178 (P. somewhat nervous).

Case17 M. C. aet. 61. Station-master.

Disease: - Sub-acute Glaucoma (R.)

History: - P. was admitted to R.I.E. on Dec. 2nd 1910 with the following history: - One year before P. had pains in the R.E. and an "attack of inflammation" which yielded to mild treatment. Sight has been gradually failing since.

R.V. 6/18- L.V. = 6/6. B.P. 130. R. pupil does not react to light. Cupping of disc T +1.

R.E. was trephined by Dr. Mackay on Dec. 7th. 1910.

P. was discharged on 16th Dec. On Dec. 24th R.V. 6/24-.

L.V. 6/6-. B.P. 138.

8/ 2/12

Condition of the Eyes: - L. pupil reacts; ant. ch. not shallow. In R.E. coloboma upwards and "filtering cicatrix" from trephine. Both discs are pale.

Veins in L.E. are much more dilated than in R.E.

R.V. = 6/18. L.V. = 6/6-.

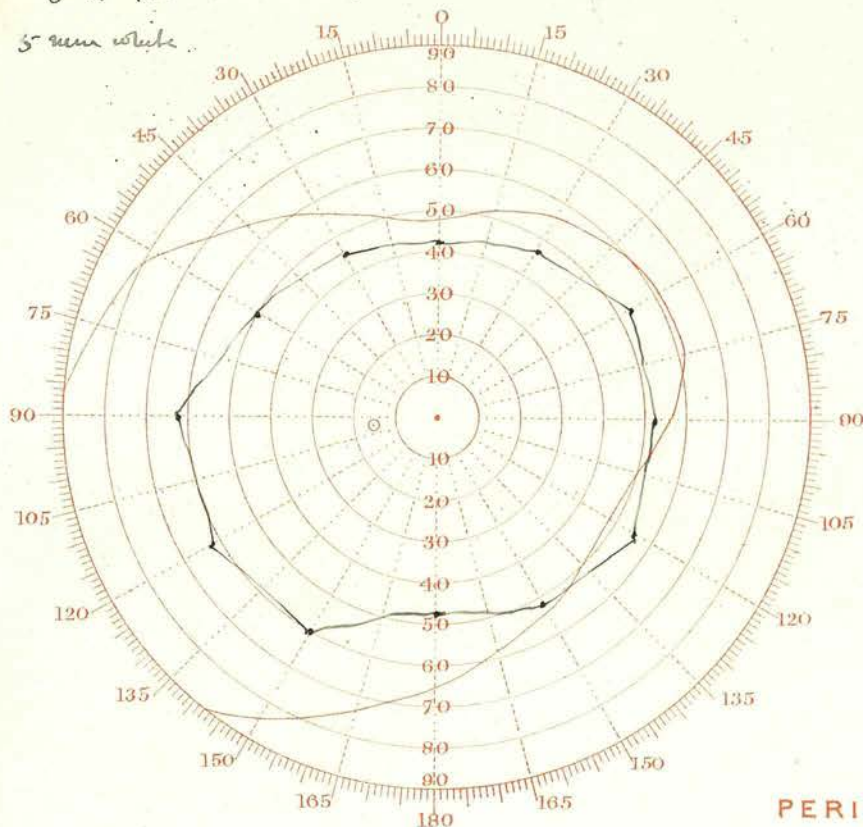


MacLeod Grant "Centre each chart with 'pointer' at Zero before

8.11.12

5 mm white

LEFT.



PERIMETER

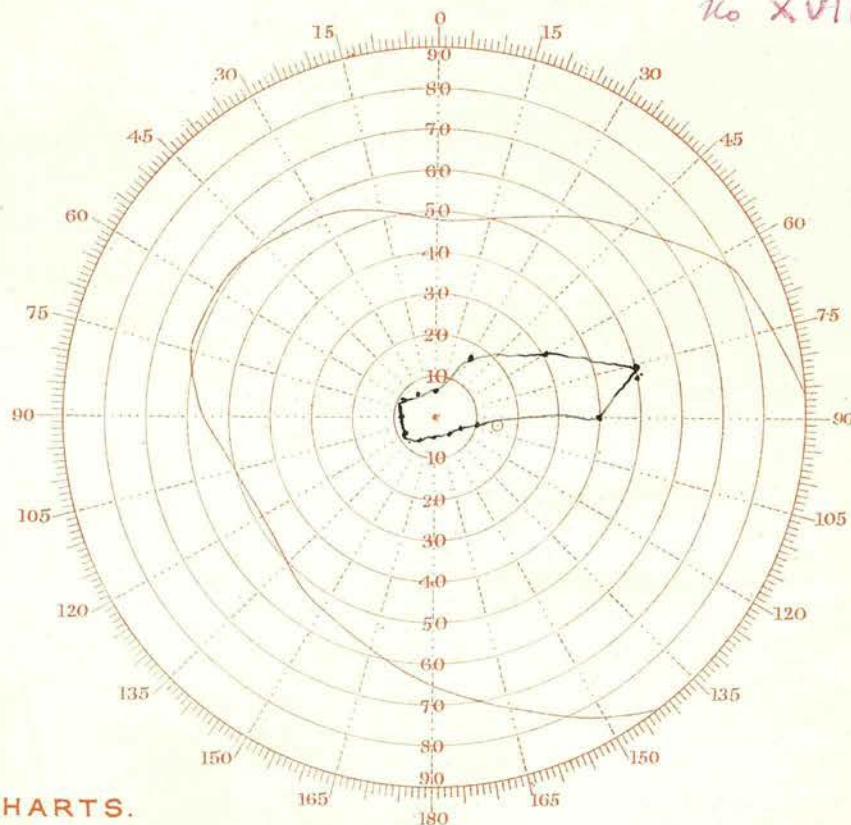
The eccentric continuous red line indicates the average normal Field.  
Designed for use with Prof. McHardy's Registering Perimeter.

commencing to use the Automatic Registration."

RIGHT.

*Glaucome Case*

*No XVII*



R CHARTS.

of Indirect Vision: the small red circle the position of the blind spot.

Published by Messrs Currie & Parton, 195, Gt Portland St London W

127.

Pressures: R.E. 25-30-26  
(12.30p.m.) L.E. 23-19½  
B.P. 120.

There is pitting on pressure in both eyes all round corneae most marked over trephine cicatrix.

Case 13 J.F. aet. 60. Farmer.

Disease: Simple Chronic Glaucoma (L.E).

7/11/11.

History: R.E. Removed (for an injury) in childhood.

L.E.: For last two years has been losing the sight. diplopia and haloes; Vision usually best in the morning. His field of vision is contracting, - knocks up against people in the street. He has never had any pain in the eye. Dr. Mackay notes:-  
Condition of Eyes.: Ant.ch. fair; field much restricted, but curiously good on nasal side inferiorly; deep cupping of disc. L.V. with -2.5 sph. -0.5 cyl. 90° = 6/12- with correction<sup>for</sup> presbyopia, reads J1, slowly.

. Pressures:- L.E. 65.

B.P. 133.

Arteries are slightly tortuous and thickened, but not atheromatous.

Subsequent history: Eye was trephined by Dr. Mackay on Nov. 3th.

21/11/11.

Pressures: L.E. 13.

(11a.m.) B.P. 144.

Case 19 Miss A. aet. 60.

Disease: Acute Glaucoma.

17/11/11.

History: L.E. enucleated for Glaucoma in July.

R.E. had excellent vision - P. able to do fine fancy work - until lately, 15th Nov., when eye became suddenly inflamed and painful.



Condition of Eye:-Cornea steamy; eye congested.  
V. = C.F. at 10 feet.

Pressures:-R.E. 39-33-32

(12 noon) B.P. 165-188. Urine alb. 0.

P. had been sitting propped up in bed before the pressures were taken. She lay on her back without a pillow for 12 minutes while pressures were being taken.

In order to see if a return to the other position would affect the readings she sat up again for 7 minutes, but pressures, -B.P. and intra-ocular -, taken immediately on lying down thereafter, were the same as the last readings taken previously.

Subsequent history:-

19/11/11. Posterior sclerotomy performed by Dr. Mackay.

21/11/11. Eye trephined by Dr. Mackay:-

9.50 a.m. P. brought into the operating room.

Pressures: R.E. 100

B.P. 206 (left arm).

10. B.P. 202.

Dr. Mackay performed venesection from right arm, withdrawing eleven ounces of blood.

B.P. fell to 192, but

R.E. remained at 100.

10.24 Chloroform begun.

10.45 After operation over B.P. had fallen to 182.

Note: Trephining was done inferiorly because of the position assumed by the eye under  $CHCl_3$ . The disc removed was right over the iris root. Iris did not bulge but was grasped and pulled out and a small iridectomy performed. The iris did not come out readily, being evidently very adherent, and the coloboma did not quite reach the inner margin.

24/11/11. 1 p.m. B.P. 144

28/11/11. 2 p.m. B.P. 136 (taken in the middle of lunch).

20/1/12. 11a.m. R.E. 21

B.P. 180-160 (Pulse 104).

23/2/12. P. is now reported to see well enough to take a hand at Bridge; and to enjoy the theatre and even to describe the dresses worn on the stage!

Case 20 J. G. aet. 56. Sawyer.

Disease: Simple Chronic Glaucoma.

11/1/12.

History:—P. dates his eye-trouble from a blow on L.E. four years ago, a month or two after which he began to see rings. The eye became totally blind 13 months ago. He has never had any pain in either eye. R.E. iridectomy on Nov. 4th 1910. Trephined subsequently as iridectomy not ~~S~~ufficient.

Condition of Eyes:—L.E. Glaucoma absolutum. cornea steamy. R.E. Coloboma from iridectomy. R.V. = 6/36.  
L. V. = 0.

Pressures: R.E. 39½-33½

(2p.m.) L.E. 39- 77

B.P. 172

Note. This patient was only seen on this one occasion. On looking up the dates he gave in the R.I.E. Eye Ward Records, no reference to any such person could be found.

Case 21 Mrs. H. aet. 56.

Disease: Chronic Glaucoma.

25/11/11.

History: L.E. was completely blind for 9 years, but never painful. It suddenly became painful in Aug. '11, and was enucleated 15/8/11. P. remembers seeing haloes with this eye before the sight was lost. She now sees haloes with R.E.

Condition of Eye:—Iris reacts sluggishly to the light; Pupil moderately dilated; ant. ch. rather shallow; slight cupping of disc. R.V. = 6/10.

Pressures: R.E. 40, 36

(1.45p.m.) B.P. 150

Subsequent history: 1/12/11 R.E. trephined by Dr. Mackay

Pressures were taken on the table 11 a.m.

R.E. 26

B.P. 128.

Note. Miotics had been used for several days. Cocaine had

been instilled 3 times before pressure taken. Holo-caine was not used.

Iris presented at operation and large iridectomy was done.

14/12/11.

Pressures: R.E.  $5\frac{1}{2}$ -5

(2p.m.) B.P. 120

6/1/12 P. had some dimness in eye, due to iritis. and returned to R.I.E. on 30/12/11 for treatment. Eye is now much improved under atropine.

Pressures: R.E.  $13\frac{1}{2}$

(2p.m.) B.P. 132

19/1/12 P. returned to show herself.

Pressures: R.E.  $15\frac{1}{2}$ -14

(1.30p.m) B.P. 118. R.V. = 6/2

Case 22 Miss M. aet. 65. Nursing Superintendent.

Disease: Sub-acute Glaucoma. (both eyes).

History: (kindly supplied by Dr. Mackay from his private notes) P. first came under observation in 1898, when glasses were prescribed. R.+0.25 D. sph. -3 D cyl165°.

L. -1 D. sph.

Her vision then was with glasses R.V., 6/12 L.V., 6/6. J1, in both eyes.

In 1907 she returned complaining of neuralgia when tired, pain in both eyes on reading and haloes. These symptoms as a rule disappeared after sleep. It was noted that both pupils reacted well; there was some venous pulsation in the R.E., but no definite cupping. Vision in both eyes as in 1898. Pilocarpine was ordered.

In July 1907 vision as before; haloes still seen, especially after being in a hot atmosphere e.g. in church or at meetings. The T. was +? At this time P. had symptoms of heart trouble and was ordered nitrites and iodide by Dr. Gibson.

In 1908 Dr. Gibson reported that her B.P. which had been high was down to 150, - a figure which he considered almost normal for her age.

In May '08 P. had some oedema of the ankles &c. B.P. 180, still using pilocarpine.

In Mar. '09 she was fairly free from haloes, Dr. Mackay was afraid that the pilocarpine might be causing adhesions and stopped it for a time.

In July '09 P. reported that during an attack of influenza she had had haloes and neuralgia. B.P. 148.

Pilocarpine was again prescribed once daily.

In Feb. 1911 P. complained of seeing haloes daily and of a stiff feeling in the eyes. An interesting point was that a day spent in bed, especially if lying on her back, brought on the haloes, whereas sleeping at night lying on her side did not cause haloes.

Vision as in 1907.

March 13th 1911. On this date Dr. Mackay had his first opportunity of observing the eye at a time when the P. saw haloes. Previously they had been slight and elusive. On this date P. had been writing a good deal and she felt the R.E. dim and painful.

When seen the cornea was steamy; iris rather fixed and T.+ R.V. = 6/60, guesses 6/36. Next day the R.V. had risen to 6/12-.

Dr. Mackay thought there was slight cupping in the eye. He advised operation.

On 25th May the R.E. was trephined. The B.P. before operation was 147 (Riva-Rocci).

On 26th May at 10 p.m. P. had an acute attack in the L.E. T.+2 &c. Under vigorous treatment (wet cupping &c.) the condition subsided.

On June the 3rd R.V. with -4 D cyl 150° = 6/18. L.V. with previous glass, 6/9-; both fields good for fingers.

B.P.<sup>175</sup> Dr. Gibson reported that P. had chronic interstitial nephritis and arterio-sclerosis.

On June 29th 1911 Dr. Mackay trephined the L.E.

July 28th. R.V. with glasses 6/9- J1.

L.V. 6/13-, with glasses 6/9 J1.

17/11/11.

Condition of Eyes.: Coloboma upwards in both eyes, from iridectomy and apparently filtering cicatrix from trephine. Discs not markedly cupped.

Pressures R. 0

(6.30 p.m.) L. 21

B.P. 200 in each arm.



Radials are thickened and tortuous.

6/III/12.

Pressures: R.E. 4-2

(6.30p.m.) L.E. 21-18

B.P. 122

Lunch at 1.30p.m.

Case 23 Miss C. aet. 54, Clerkess.

Disease:—Simple chronic Glaucoma (both eyes).

History:— P. consulted Dr. Paterson 4 days ago for glasses. She had had an attack of what her doctor called iritis, in the L.E. some two months before.

14/12/11.

Condition of Eyes:—Discs: Slight cupping and vessels pushed to nasal side; most marked in R.E.

Fields in both eyes almost sharply limited upwards by the equator. R.V.=6/6 nearly, L.V.=6/6+.

Pressures: R.E. 39-36

(4p.m.) L.E. 35

B.P. 132.

Subsequent history: Dr. Paterson trephined the R.E. on January the 7th.

1/2/12. Pressures: R.E. 19½-18.

(3.30p.m.) L.E. 31 (Eye is under pilocarpine.)

B.P. 132.

Case 24 D.B. aet. 53 .

Disease: Prodromal Glaucoma (L.E.)

11/1/12.

History: P. came yesterday to see Dr Traquair at Lauriston Dispensary suffering from an acute glaucomatous attack in L.E.

Notes by Dr Traquair: L.V.= C.F. at 6 metres T. +2 cornea hazy; eye congested; considerable pain.

R.V. with +3 D. sph. = 6/6-.

Three instillations of ½% eserine were given and one application of powdered dionin. He was ordered eserine ½%, pilocarpine 1% to be used t.i.d.

133.

P. reports that the pain ceased about 4 p.m. yesterday shortly after returning from the Dispensary and his vision improved.

Condition of Eyes: -

R.V. with 3 D sph. = 6/6-.

L.V. with 2 D. sph. = 6/18.

Cornea is now clear; eye still slightly congested; disc can now be seen; -there is no cupping but veins are rather dilated.

Pressures:— R.E. 21-18

(2p.m.) L.E. 23-18

B.P. 160.

Case 25 G.B. aet. 52, Farm-servant.

Disease:— Simple chronic Glaucoma. (R.E.)

12/12/11.

History:— P. dates his trouble from some dirt getting into his R.E. about 6 weeks ago. His wife died ~~died~~ two months ago and he had a great deal of night nursing and anxiety before that time. He has had occasional attacks of dimness in the eye, -gradually growing worse. Eye often best in morning and getting worse at night, sometimes almost clear in the middle of the day. No haloes and no pain, -only slight discomfort.

Condition of Eyes:—

Ant.ch. shallow in both eyes; pupils moderately dilated; cornea small.

Fundus: veins greatly dilated in both eyes, especially in the R.E.; no cupping.

Fields: considerably diminished in both eyes, but especially in the R. which shows Bjerrum's sign.

R.V. with -1 D. sph. -1.5 cyl.  $110^{\circ}$  = 6/6-.

L.V. with -0.5 D. sph. = 6/6-.

Pressures:— R.E. 65-51

(12.30p.m) L.E.  $16\frac{1}{2}$ - $14\frac{1}{2}$

B.P. 122. urine: alb. O.

Note remarkably low pressure in one of his age & occupation.

Subsequent history:

Case 25  
contd.

14/12/11.

Pressures: R.E. 51-47

(1.30p.m.) L.E. 18-15

B.P. 130.

Venous Pressure 9mm.Hg. - veins collapse  $4\frac{1}{2}$  inches above level of apex.

20/12/11.

P. has been using pilocarpine  $1\frac{1}{2}$  b.d. in R.E. since 14/12/11.

Pressures: R.E. 39

(1p.m.) L.E.  $15\frac{1}{2}$

B.P. 115

22/12/11. R.E. trephined by Dr Paterson.

5/1/12.

Pressures R.E. 11-10

(noon) L.E. 17-14 $\frac{1}{2}$

B.P. 118

P. sees much better with the R.E. since operation.

20/1/12. P. has been at work for a fortnight, — during the last week doing full work.

Pressures: R.E.  $15\frac{1}{2}$ -14 $\frac{1}{2}$ .

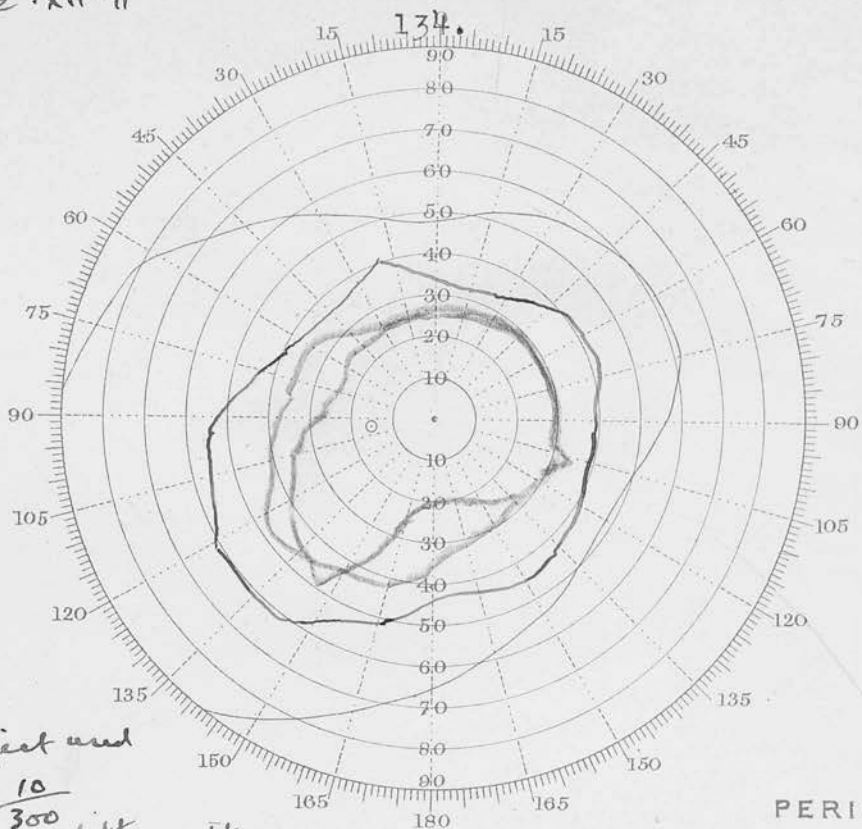
L.E. 16 $\frac{1}{2}$ .

B.P. 128.

George Black  
 act 5-2  
 12.XII.11

Centre each chart with pointer at Zero before

LEFT



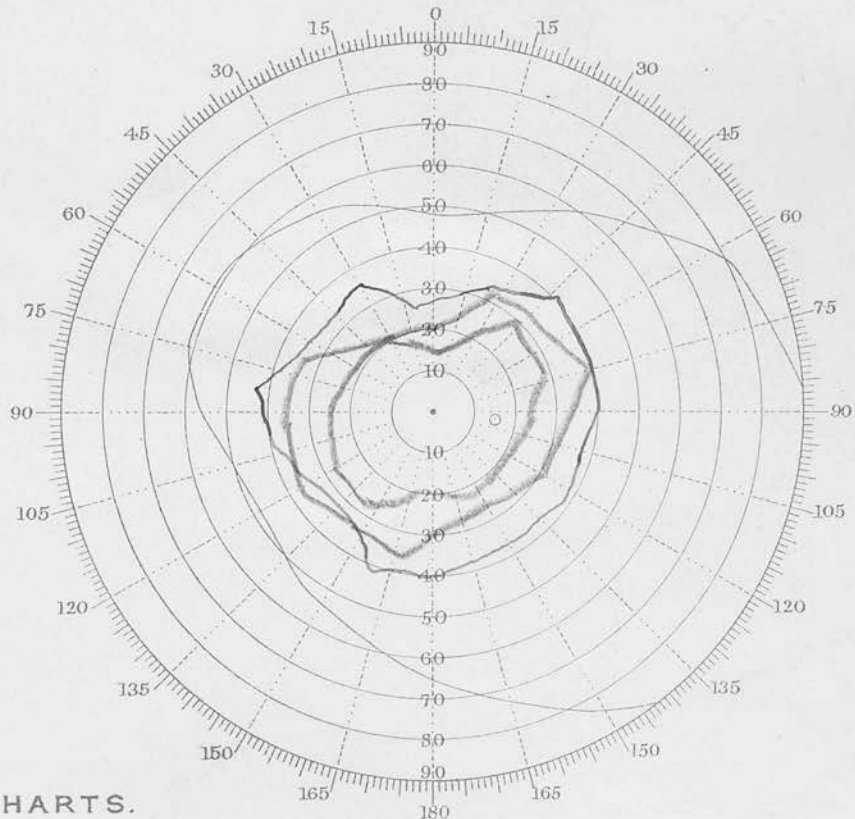
Object used

$\frac{10}{300}$   
 1 P.m. daylight  
 moderately bright.

The eccentric continuous red line indicates the average normal field.  
 Designed for use with Prof. M<sup>c</sup> Hardy's Registering Perimeter.

commencing to use the Automatic Registration.

RIGHT *Glaucoma Case No XXV*



R CHARTS.



Case 26 W.B. aet. 51

Disease:- Sub-acute Glaucoma (both eyes).

History:- P. came to R.I.E. in Feb. 1911 and was ordered glasses R. +2.5 D. sph. +0.5 cyl. 145°. L. +5 D. sph. +0.5 cyl. for distance. He had had some discomfort in the L.E. in Jan. after a period of hard work and worry.-the sensation being that of a foreign body in the eye. He had noticed haloes for some time before this.

In June 1911. Dr Mackay trephined his L.E. It was noted before operation that the L. field was greatly diminished with a nasal step, the R. field being fairly normal.

July 24th R.V. with glasses 6/12. reads J4.

L.V. .. 6/8-, reads J6.

Pilocarpine was prescribed.

15/11/11.

P. now sees rings with R.E. and has had some pain in it.

Condition of Eyes:-

R. pupil reacts sluggishly; ant.ch. shallow; cornea somewhat steamy; disc slightly cupped.

L. coloboma upwards from iridectomy; iris does not react; slight cupping of disc.

R.V. with glasses 6/8-. L.V. 6/8-; fields as noted above; -no nasal step in R.E.

Pressures:- R.E. 33½-23½.

(2.30p.m.) L.E. 17-8½.

B.P. 134.

Subsequent history:- R.E. trephined by Dr Mackay on Nov. 13th-

24/11/11.

Pressures:- R.E. 13½

(10.30a.m) L.E. 17

B.P. 126.

Feb. 23rd 1912 P. came up to report himself.

Pressures: R.E. 7½-8½

(3p.m.) L.E. 12-10

B.P. 126.

R.V. with glasses. 6/12, L.V. 6/8-.

Case 27 Mr. R. aet. 48, Lawyer.

Disease: - Chronic Glaucoma, ending in acute Glaucoma.

History: - L. Eye blind from Chronic Glaucoma for over a year. P. had no pain in it till six weeks ago he had a sudden acute attack. He came to Edinburgh as soon as he was able to travel and the eye was trephined by Dr. Paterson on 1/12/11.

At the operation roots of iris proved very adherent and friable. No iridectomy proper was done.

12/12/11.

Condition of Eyes: - R.E. Iris reacts to light; there is no cupping, and, so far as tested, no diminution of field; disc a little redder than normal.

L.E. Trephine scar above cornea.

Pressures: - R.E. 45-48.

(5p.m.) L.E. 36-45

B.P. 140.

26/2/12.

R.E. has normal ant. ch. and pupil; normal fundus and undiminished field. R.V. with +4 D. sph. = 6/6.

L.E.: There is some bulging downwards over the cornea of tissue at site of operation wound; small sub-hyaloid haemorrhage above the disc; disc atrophied and deeply cupped.

Pressures: - R.E. 36-39. (P. has been using 1% (5p.m.) pilocarpine once daily.)

L.E. 45. (After massage through the lid for 30 sec. pressure fell to 41.

B.P. 136.

Case 23 J.G. aet. 43, Van-man.

Disease: Simple chronic Glaucoma.

14/11/11.

History: Three months ago noticed sight for distance getting poor; and that his eyes got very sore on reading for half an hour in gas-light; haloes also. Sight best through the day, worse in morning and

at night; good in early morning, after beginning work gets worse, but as day gets brighter improves. Sight worse when tired.

No history of attacks of pain except as above.

Condition of Eyes:-

Pupils react sluggishly; ant.ch. slightly shallow  
R.E. field greatly contracted on nasal side.  
L.E. field slightly contracted in all directions  
The R. disc is cupped and there is some opacity  
of lens; L.E. disc ?cupping.

Pressures: R.E. 62-58 (P. very sensitive to  
(2.30p.m) L.E. 65-53 (holocaine)  
B.P. 118.

Subsequent history:- R.E. trephined on 17/11/11.

Eight days after operation P. developed an attack of facial Erysipelas, starting from a chronic eczematous condition about the nose, and he was sent to Fever Hospital. Eye not implicated.

16/12/11 P. showed himself on discharge from Fever Hospital.

Pressures:- R.E. 30-28  
(12.30p.m) L.E. 51-49  
B.P. 122.

Venous pressure about 12.mm.Hg.  
P. was re-admitted on 2/1/12. He has seen haloes with the L.E. since going home. The L.E. was trephined on 9/1/12.

19/1/12. before final discharge from Hospital

Pressures:- R.E. 21  
(1p.m.) L.E. 18-17  
B.P. 112

CASE 29 Mrs..W.aet. 46.

Disease: Acute Glaucoma.

16/1/12.

History: P. has had attacks of dimness of vision and haloes when tired, for years. These always dis-

appeared after rest, e.g. in bed. About 2 years ago had an acute attack in L.E. and lost the sight. The L.E. was enucleated 18 months ago. On Jan. 1st. 1912, after a period of extra strain, P. had an acute attack in the remaining (R.) eye, and was kept in bed by her doctor until now.

Condition of Eye:—Pupil widely dilated and immobile; cornea steamy; disc not visible; eye intensely congested. V. = H.M. at 4 inches.

Pressures: R.E. 96

(2p.m.) B.P. 172, Pulse 92. P. very nervous. Urine normal.

18/1/12.

On admission on 16/1/12 P. was cupped from right temple. She has had pilocarpine 1% t.i.d.

Pressures: R.E. 70

(1p.m.) B.P. 140

19/1/12 Trephined.

1/2/12. Since operation P. generally wakens with pain in eye. Eye waters. Pain goes away in an hour or so. Pain sometimes wakens her at night. This morning no pain. V. = P.L. to outside, but P. states that sometimes she can notice people moving in the Ward.

Pressures: R.E. 27½-28

(1.30p.m.) B.P. 130.

P. returned from Convalescent Home to report at R.I.E. Her vision has improved considerably and is now 2/60. She has a limited field to the temporal side.

Pressures: R.E. 30-28

(3p.m.) B.P. 153. (P. nervous.)



Case 30 J.A. aet. 45. male.

Disease:—Chronic Glaucoma (R) in myopic eye, with cataract in the other eye (L.)

History: Sight of L. (cataractous) E. began to fail 5 years ago; has got much worse in last 6 months.

R.E. has been failing for last 6 months and during last month P. has seen haloes. This eye gets very painful on reading for any length of time.

19/12/11.

Condition of Eyes:—L.E. cataract. Projection good; pupil reacts to light. V. = H.M. at 2 feet. R.E. pupil reacts to light and accommodation; V. with -14 D.sph. = 6/36-. cornea clear; field: —nasal step; fundus: small sharply defined spots of choroidal change especially round macula; veins somewhat dilated; slight cupping.

Pressures:— L.E. 18-17 (On applying the tonometer (12 noon) R.E. 47-45 (ometer it was evident that the corneae were much larger than usual) B.P. 133. urine normal.

Further history:

22/12/11 Admitted to R.I.E.

29/12/11 Dr Paterson operated for cataract in the L.E. — vitreous was fluid and extraction difficult. Some lens matter had to be left behind.

13/1/12. Pressures: L.E. 0 (3p.m.) R.E. 35½-31. (P. has had a miotic b.d. for some time)

B.P. 120

17/2/12. P. has been at home for a week after returning from Convalescent Home.

Pressures: R.E. 43-39½ (P. has had no miotic (2p.m.) L.E. 1mm. since leaving Hospital.)

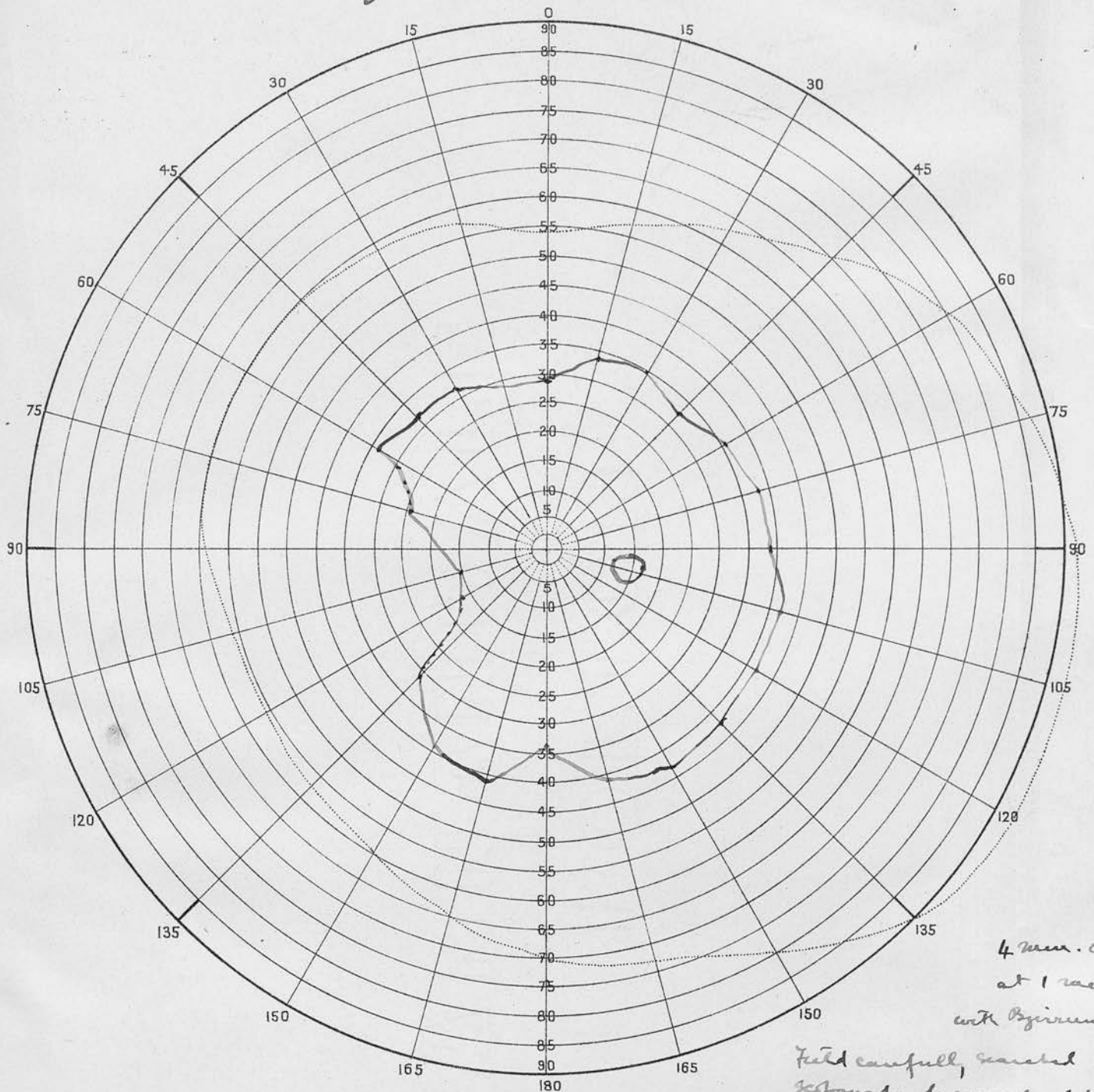
B.P. 118.

R.V. 2/30 with -14 D.sph. slightly improved with a higher lens. A chart (Q.V.) taken with Bjerrum's screen showed a well-marked nasal diminution of the field with a nasal step. A careful search was made for scotomata correspond-

140.  
RIGHT

V  $\frac{3}{60}$   $\bar{c} - 142$

Glaucoma Case XXX



4 mm. object  
at 1 metre  
with Byrnes Screen.

Field carefully searched for  
distortions to correspond to choroidal  
patches, but not distinguished.

Name James Allen

Date

17/2/12

ing to the choroidal patches round the macula, but none could be detected.

Case 31 Mrs M. aet. 44.

Disease:- Sub-acute Glaucoma.

History:- P. has had failing sight in L.E. for 5 years but no pain. Sight not improved by glasses.

Came to R.I.E. 12/8/11 and was trephined by Dr Sinclair, on 15/8/11 for Glaucoma in L.E.

12/10/11 L.V. with +1.5 D. sph. = 6/24-.

On 19/10/11 P. had an acute attack with great pain in L.E. and headache. Next day no pain. But pain resumed 21/10/11 and P. came to R.I.E.

27/10/11.

Condition of Eyes:-

R.E. shallowed ant. ch. but otherwise normal.

L.E. congested, trephine mark above.

Pressures: R.E. 33-23.

(10.30a.m) L.E. 70-39.

(P. in bed) B.P. 144. urine normal.

Subsequent history:-

3/11/11. Trephine wound re-opened by Dr Mackay and some iris removed. There was some escape of vitreous and no further attempt was made to remove iris.

17/11/11. Pressures:- R.E. 33-23.

(1.55p.m) L.E. 19½-18.

B.P. 153.

25/11/11. P. returned as O.P. to show herself. The lens is now opaque in the L.E.; ant. ch. very shallow.

Pressures:- R.E. 33-20.

(2.20p.m) L.E. 30-25.

B.P. 150.

14/12/11. Since 25/11/11 P. has been using pilocarpine 1% t.i.d. and taking erythrol tetranitrate gr. ½ b.d..

Pressures:- R.E. 21-13½

(12.30p.m) L.E. 23-22.

B.P. 130.

4/1/12. P. has used pilocarpine in R.E. once only per diem since 14/12/11. Has had some discomfort (hardly pain) in L.E.

Pressures: R.E. 32-22.

(1.30p.m) L.E. 32-29.

B.P. 133.

Case 32 J.F. aet. 39, Crane-man.

Disease: Chronic Glaucoma.

17/1/12.

History: For 18 years P. has seen haloes occasionally with L.E. sometimes also with R. Never any pain. Attacks come on when P. is seedy. P. has hypermetropic astigmatism +3.5 D. sph. +1.5 D. cyl. ↑.

His vision at present is worst in morning; gets clearer as day goes on. He has had the present attack of haloes and of dimness for 5 days. Has been using pilocarpine for 3 days.

Condition of Eyes:-Pupils react to light; media clear; ant. ch. not markedly shallow; no definite cupping; doubtful in L.E. R.V. with glasses 6/9

L.V. .. 6/6-.

Pressures: R.E. 13-14½

(4p.m.) L.E. 47½-48

B.P. 133

Venous pulsation marked in both eyes and arterial pulsation present in affected (L.) E., which has the better vision; fields: no marked diminution.

19/1/12 P. has discontinued pilocarpine since last seen, but has worn his glasses constantly. He has never worn glasses previously except for reading.

Pressures: R.E. 12½

(1p.m.) L.E. 32½

B.P. 152.



## APPENDIX II.

## EYE PRESSURE IN NORMAL EYES.

(Cases from my 'Control' Series.)

	Case No.	R.	L.
<u>Ages.</u> 60-69	( 5	17	-
	( 8	$19\frac{1}{2}$	$19\frac{1}{2}$
	( 12	$14\frac{1}{2}$	$14\frac{1}{2}$
	( 14	-	18
50-59	( 18	-	17
	( 19	17	17
	( 29	18	18
	( 32	-	22
	( 33	21	23
	( 36	-	$19\frac{1}{2}$
40-49	( 37	18	18
	( 38	$15\frac{1}{2}$	$15\frac{1}{2}$
	( 39	21	-
	( 42	$16\frac{3}{4}$	$16\frac{3}{4}$
	( 44	$14\frac{1}{2}$	$15\frac{1}{2}$
	( 46	17	17
	( 47	19	19

	<u>Case No.</u>	<u>R.</u>	<u>L.</u>
<u>Ages.</u> 30-39	( 48	-	25
	( 49	21	23
	( 50	$19\frac{1}{2}$	-
	( 51	23	25
	( 53	$15\frac{1}{2}$	-
	( 54	12	-
20-29	( 55	18	18
	( 57	17	17
	( 58	18	18
	( 59	20	20
	( 60	12	12
	( 63	-	$15\frac{1}{2}$
Under 20	( 64	$19\frac{1}{2}$	-

# EYE PRESSURES AND AGE IN NORMAL EYES.

Ages 60-69	6 eyes	103	av.	17.16
" 50-59	8 eyes	153	av.	19.12
" 40-49	14 eyes	243	av.	17.35
" 30-39	10 eyes	200	av.	20.00
" 20-29	9 eyes	$149\frac{1}{2}$	av.	16.61

## APPENDIX III.

Pressures in Myopia (excluding low Myopia Astigmatism)

<u>Case No.</u>	<u>Age</u>	<u>Degree of Myopia.</u>	<u>Complication.</u>	<u>R.</u>	<u>L.</u>	<u>Notes.</u>
IX.	63	-4	Cataract.	18	18	
X.	62	>20	Cataract & Choroiditis.	9	8½	R.E. had been op. on.
XX.	58	-2.5	Cataract	15½ 12½	15½ 12½	Pressures taken on 2 occasions.
XXXV.	49		Disseminated Choroiditis.	14½	15½	
XXXVIII.	47	-1.5	-	14½	15½	
XLIII.	46	R.-4 L.-7	Choroiditis.	6½	10	
XLIV.	46	-2	-	14½	14½	
XLV.	45	> 25	-	15	15	
LII.	35	R.-12 L.-19	Detachment in L.	(19½ (12	0 2	Pressures taken on 2 occasions.
LVI.	31	15	-	18	18	
LXI.	23		Choroiditis; Secondary Glaucoma in R.	(25 (18	13½ 16¾	R.E. has been op. on.

## APPENDIX IV.

Notes on Cases among my 'Controls', in whom I found  
an intraocular pressure above Schiötz's limit of  
25 MM. Hg.

(1) Case III. P. of 75, with senile cataract in L. eye. The pressure in this eye when first taken was 30, but diminished very rapidly under successive applications of the tonometer to 21. The pressure in the R.E. was 23, falling to  $19\frac{1}{2}$ .

(2) Case XI. P. of 62 with secondary glaucoma in R.E. Pressure: R.,  $27\frac{1}{2}$ ; L., 21.

(3) Case XXIII. P. of 56 with recent dislocation of the lens in a highly degenerate eye.

(4) Case XXVI. P. of 54 with iridocyclitis in R. eye. The eye pressure was 65 mm. Atropine was given and the patient urged to return to R.I.E. for admission. She was not seen again.

(5) Case XXVIII. P. of 54 with hypermetropic astigmatism of 4D, and poor vision. This patient was dropsical - suffering from heart disease and albuminuria. The pressures in each eye were 34, falling rapidly to 26. P. was in an exhausted condition, and it was impossible to make further observations/



observations with regard to fields, etc.

(6) Case XXXI. P. of 52 with irido-cyclitis in L. eye. Pressures 43-39. R.E.,  $14\frac{1}{2}$ . Under treatment with atropine, leeching, etc., the pressure in L.E. fell to 18.

(7) CASE XXXII. P. of 51 who had had an injury to R.E., and subsequent iritis. Pressure: R., 30; L., 22.

(8) Case XXXVI. P. of 48 with secondary glaucoma in R.E., following injury eleven years before, and subsequent iritis.

(9) Case XXXIX. P. of 47 with secondary glaucoma in L.E. This eye had been operated on more than ten years before for unsightly congenital cataract. The pressures were R., 21, L., 70-62. Under treatment the pressure fell in L.E. to 21 after some days.

(10) Case XLVIII. P. of 38 with detachment of retina one year previously in R.E. The corneae in this case were very small. P. had been operated on for cleft palate in childhood. Pressures R., 39-40, L., 25-16. As the R.E. had had a drop of cocaine before examination, one drop of eserine was instilled, and the P. asked to return next day. His pressures then were R., 35-33, L., 19.

(11) Case LIII. P. of 34 with secondary glaucoma in L.E. Pressures: R.,  $15\frac{1}{2}$ -13; L., 70-68.

---

## APPENDIX V.

Notes on eyes which had not been operated on, in both my series of cases (Glaucoma and Controls), in which I found tensions below Schiötz's limit of 15.5 mm.Hg.

- (1) Case X. P. of 62 with high myopia (>20D) and cataract. The L.E. was 8.5. (R.E. has been operated on; its pressure was 9.)
- (2) Glaucoma Case XV. P. of 62 with glaucoma in L.E. The R.E., in which there were widespread choroidal changes, had a pressure of 14.5 on two occasions; once 15.5.
- (3) Case XII. P. of 60 with "watery eyes" and slight hypermetropia (+1D). Both eyes were 14.5.
- (4) Case XVI. P. of 60 living in the medical wards with a gastric tumour (?). Both eyes were 14.5.
- (5) Case XVII. P. of 59 with double cataract. Both eyes were 12.75.
- (6) Case XVIII. P. of 58 with detachment of retina in R.E., two months previously. Pressure was 12 (other eye, 17-13.5).
- (7) Case XX. P. of 58 with double cataract. The pressures were R.,  $12\frac{1}{2}$ ; L.,  $13\frac{1}{2}$ . (Pressures taken several minutes after instilling holocaine.)/

holocaine.) On other occasions both had been  $15\frac{1}{2}$ - $13\frac{1}{2}$ .

(3) Case XXXI. P. of 52 with irido-cyclitis and increased tension in L.E. Pressures in R.E. on two occasions were  $14\frac{1}{2}$  and 12.

(9) Case XXXV. P. of 49 with myopia and choroiditis (peripheral). R.E.,  $14\frac{1}{2}$ ; L.E.,  $15\frac{1}{2}$ .

(10) Case XLIII. P. of 46 with myopia (R., -4; L., -7D), and central choroiditis. R.E.,  $6\frac{1}{2}$ , L.E.,  $10-7\frac{1}{2}$ .

(11) Case XLIV. P. of 46 with myopia of 2D. R.,  $14\frac{1}{2}$ , L.,  $15\frac{1}{2}$ .

(12) Case XLV. P. of 45 with extreme myopia (>25D). R.E., 15; L.E., 15.

(13) Glaucoma Case XXXII. P. of 39 with prodromal glaucoma in L.E. R.E. on one occasion gave a pressure of  $12\frac{1}{2}$ ; on another of  $18-14\frac{1}{2}$ .

(14) Case LII. P. of 35 with high myopia (R., -12; L., -19D), and recent detachment of retina in L.E. The pressure in L.E. was 0 (in R.,  $19\frac{1}{2}$ ). After a month in hospital, the pressure in L.E. had risen to 2mm., the R.E. was 12.

(15) Case LIV. P. of 32 with sarcomatous growth on L. eyeball and in L. orbit. P. was an energetic/

energetic, healthy-looking man. His R. eye looked normal in every way, and R.V. =  $6/6$ , but his pressure in R.E. on one occasion was 9, on another 12.

(16) Case LX. P. of 26, (recently recovered from Pott's disease), in good health, with normal-looking eyes and V.6/6, but pressures were  $12-8\frac{1}{2}$ .

(17) Case LXI. P. of 23 with high myopia (8D), with wide-spread choroidal changes, history of iritis, etc. L.E.,  $13\frac{1}{2}$ , on another occasion  $16\frac{3}{4}-12\frac{3}{4}$ .

(18) Case LXIII. P. of 22 with retro-bulbar neuritis in R. L.E.,  $15\frac{1}{2}$ ,  $13\frac{1}{2}$ ,  $14\frac{1}{2}$ , on three separate occasions.



## APPENDIX VI.

## REFERENCES.

1. PARSONS. *Lancet*, Vol. I., p. 15, 1912.
2. CRIDLAND. *Ophthalmoscope*, September, 1910.
3. FUCHS. *Text-Book of Ophthalmology*, trans. by Ducane, 4th Edition, 1911, p. 19.
4. MARPLE. *Trans. Amer. Ophthalm. Soc.*, Vol. II., 1910.
5. KRÄMER. *V. Graefe's Arch. f. Oph. Bd. LXXIII.*, 1910.
6. GILBERT. *V. Graefe's Arch. f. Oph.*, Bd. LXXX.
7. SCHIÖTZ. *Arch. f. Augenheilkunde*, Bd. LII., No. IV.
8. SCHIÖTZ. *Arch. f. Augenheilkunde*, Bd. LXII., No. IV.
9. VAN GELDER. *Klin. Monatschr. f. Augenheilkunde*, Nov. 1911.
10. LANGENHAN. *Centralblatt f. prakt. Augenheilkunde*, 1909, p. 323.
11. STOCK. *Klin. Monatschr. f. Augenheilkunde*, Bd. XLVIII.
12. MARPLE. *Trans. Amer. Ophth. Soc.*, Vol. II., 1910, p. 552.
13. OEDING. *Inaug. Dissert.*, Rostock, 1910.
14. STOCK. *Klin. Monatschr. f. Aug.*, XLVIII.
15. V. GRÖNHOLM, quoted by, *Archives of Ophthalmology*, Nov. 1911.
- 16./

16. V. GRÖNHOLM. Arch. of Oph., Nov. 1911.
17. - L'Ophtalm. Provinc., Mar. 1909.
18. TERSON & CAMPOS. Archives D'Ophtalmologie,  
April 1898.
19. JOSEPH: Thèse de Paris, 1904.
20. KRÄMER. V. Graefe's Arch. f. Oph., Bd. LXXIII.,  
1910.
21. FRENKEL. Archives d'Ophtalmologie, Vol. XXV.,  
Jan. 1905.
22. BAJARDI. Giorn. della Acad. di Medic. di  
Torino, LXV., 1900.
23. KUEMMELL. V. Graefe's Archiv. f. Ophthalmologie,  
LXXIX., 1911, p. 133, ff.
24. - Lancet, 1908, Vol. II., p. 1617.
25. GIBSON. Edin. Med. Journal, Mar. 1911, p. 200.
26. LEONARD HILL. Lancet, 1909, Vol. I., p. 944.
27. RUSSELL. Arterial Hypertonus Sclerosis and  
Blood Pressure, p. 22, ff. 1907.
28. RUSSELL. Loc. Cit., p. 54.
29. WILLIAMSON. Brit. Med. Journal, Feb. 1909.
30. CAMPBELL. Lancet, Vol. I., 1910, p. 944.
31. OLIVER. Résumé of Recent Clinical Studies in  
Atheroma and Arterio-sclerosis, 1908,  
p. 20, ff.
32. OLIVER. Studies in Blood Pressure, 3rd Edit.  
1908.
33. OLIVER. Loc. cit., p. 115.
34. HENDERSON & STARLING. Journal of Physiology,  
Aug. 1904.
- 35./

35. WESSELY. Archiv. f. Augenheilkunde, LX.,  
pp. 1-97.
  36. " Quoted by Krämer, loc. cit.
  37. DUNN. Arch. of Ophthalmology, Nov. 1908. p.687.
  38. JACKSON. Ophthalmic Record, Oct. 1909.
  39. FOX, WEBSTER & BATROFF. Ophthalmic Record,  
Oct. 1908.
  40. RONN. La Clinique Ophthalmolog., Dec. 10. 1909.  
vide Ophthalmoscope, 1910, p. 150.
  41. GILBERT. V. Graefe's Archiv. f. Ophthalmologie,  
Vol. LXXX., p. 238.
  42. JOSEPH. Thèse de Paris, 1904.
  43. EDWIN MATTHEW. Lancet, Jan. 1909, p. 240.
  44. THOMSON HENDERSON. "Glaucoma", London, 1910.
  45. OLIVER. Studies in Blood Pressure, p. 32, ff.
  46. MAYNARD. Intra-ocular Pressure in Epidemic  
Dropsy. Ophthalmology, 1909-10,  
p. 223.
-